This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

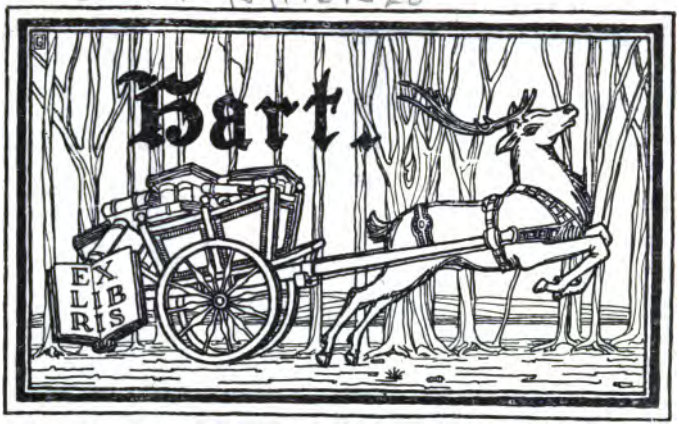
THE INDUSTRIAL READERS - BOOK FOUR

EducT
739.16
820

TRAVELERS AND TRAVELING

By Eva March Tappan

Educ T 739.16.820



Albert Bushnell Bart

HARVARD COLLEGE
LIBRARY

THE GIFT OF
ALBERT BUSHNELL HART
OF CAMBRIDGE

Class of 1900

J. L. I. S.

3 2044 097 051 213

THE INDUSTRIAL READERS

Book IV

TRAVELERS AND TRAVELING

BY

EVA MARCH TAPPAN, PH.D.

Author of "England's Story," "American Hero Stories," "Old World Hero Stories," "Story of the Greek People," "Story of the Roman People," etc. Editor of "The Children's Hour."

HOUGHTON MIFFLIN COMPANY

BOSTON NEW YORK CHICAGO

HARVARD COLLEGE LIBRARY
GIFT OF
ALBERT BUSHNELL HA
DEC 5 1923

THE INDUSTRIAL READERS

By Eva March Tappan

I. THE FARMER AND HIS FRIENDS. 50 cents.
II. DIGGERS IN THE EARTH. 50 cents.
III. MAKERS OF MANY THINGS. 50 cents.
IV. TRAVELERS AND TRAVELING. 50 cents.

The foregoing are list prices, postpaid

COPYRIGHT, 1916, BY EVA MARCH TAPPAN

ALL RIGHTS RESERVED

First printing April 1916;
Reprinted December 1916

The Riverside Press
CAMBRIDGE . MASSACHUSETTS
U . S . A

PREFACE

THE four books of this series have been written, not merely to provide agreeable reading matter for children, but to give them information. When a child can look at a steel pen, not simply as an article furnished by the city for his use, but rather as the result of many interesting processes, he has made a distinct growth in intelligence. When he has begun to apprehend the fruitfulness of the earth, both above ground and below, and the best way in which its products may be utilized and carried to the places where they are needed, he has not only acquired a knowledge of many kinds of industrial life which may help him to choose his life-work wisely from among them; but he has learned the dependence of one person upon other persons, of one part of the world upon other parts, and the necessity of peaceful intercourse. Best of all, he has learned to see. Wordsworth's familiar lines say of a man whose eyes had not been opened, —

> "A primrose by a river's brim
> A yellow primrose was to him,
> And it was nothing more."

These books are planned to show the children that there is "something more"; to broaden their horizon; to reveal to them what invention has accomplished and what wide room for invention still remains; to teach them that reward comes to the

man who improves his output beyond the task of the moment; and that success is waiting, not for him who works because he must, but for him who works because he may.

Acknowledgment is due to the American Express Company, De La Vergne Machinery Company, Boston Elevated Railway Company, Streckfus Steamship Line, Cunard S. S. Company, American Bridge Company, Packard Motor Car Company, Boston & Albany Railroad, and others, whose advice and criticism have been of most valuable aid in the preparation of this volume.

EVA MARCH TAPPAN.

CONTENTS

I. How Railroads are built and Trains are run 1
II. How the Railroads carry Mail and People . 15
III. How Refrigeration brings us Food . . . 26
IV. How Freight and Express are managed . . 36
V. About Compressed Air 44
VI. How the Trolley Car runs 54
VII. How Elevated Roads and Subways are built . 63
VIII. What the Motor Car is doing 74
IX. Transportation by Rivers and Canals . . 82
X. The Great Highway of the Ocean . . . 95
XI. About Roads and Bridges 108

THE INDUSTRIAL READERS

BOOK IV

TRAVELERS AND TRAVELING

I

HOW RAILROADS ARE BUILT AND TRAINS ARE RUN

If a group of men think that it will pay to build a railroad, the first step is to send an engineer over the ground to get a general notion of where the road should lie. He is not expected to spend a great deal of time in this exploring, but he must keep his eyes open. He must note whether the soil is of good quality for foundations, whether swamps or rivers would have to be crossed or whether they could be avoided, and on which side of a hill it would be best to go in order to escape heavy winds or snowdrifts or landslides.

After this comes a survey. It is the business of the civil engineer who makes this survey to study the several routes which are possible; to mark exact distances, the width of rivers, the varying heights of the land, the location of ledges, and the depth of any ravines that must be crossed. The engineer can now give a general idea as to how much the road will cost.

The final survey must be made with great care and

accuracy; and the engineer must know much more than simply how to use his instruments. He must be able to choose the best of the several possible routes; and this "best" is not always by any means the cheapest or the easiest. It may be cheaper and easier to go by one route; but perhaps going by another will carry the line through a town that will provide business for the road. Again, curves are not good. On a road with many sharp curves the trains must run more slowly, the passengers are not so comfortable, more fuel is needed, there is greater wear on wheels and rails, and trains cannot be either so long or so heavy as on a straight road. On the other hand, grades, too, lengthen the running time and shorten the trains, and require more fuel. The engineer must choose between the two evils. Then, too, he must consider the cost of building and the cost of running. It is expensive to dig a tunnel or build a bridge. Merely the interest on the money tied up in either of them amounts to quite a sum, and they involve greater possibility of accidents than an ordinary stretch of road. Perhaps the engineer can avoid the need of both tunnel and bridge by going two or three miles to one side. In that case he must take into account the cost of building the extra miles of road and also the extra expense and time required for the trains to run those additional miles.

Besides the surveying, other equally necessary work must be done, namely, getting a charter from the State, which shall give permission to build and

Courtesy New York Central Lines.

THE FREIGHT-YARDS OF A GREAT RAILWAY

How the yardmaster ever knows where anything is in this tangle of tracks is a mystery — but he does know. Notice the turntable outside the roundhouse for the engines.

operate the road and take tolls for carrying passengers and freight. This charter also allows the builders of the road to oblige the owners of any land that may be necessary to the railroad to sell it to the corporation for a fair price. This is hard for the people who may not wish to sell their land; but if the State did not give this right of purchase, one man might block the building of the road altogether. As a matter of fact, a new road prefers to have friends rather than enemies along its line, and is inclined to pay well for what it needs.

Building a railroad is costly. Money may be raised by the issue and sale of stocks, in shares usually of either fifty or one hundred dollars each. If the road succeeds, these shares pay to the purchaser or owner dividends, or interest on his money; if it does not succeed, he may lose all that he has put in. Money may also be raised by mortgage bonds, or promises of the railroad to pay a fixed per cent in interest. If this interest is not paid, the holders of the bonds can seize any property belonging to the railroad in order to get back their money.

The work of making the road begins with clearing a "right of way": that is, a strip of land usually from thirty to one hundred feet wide, where the railroad is to lie. Trees and bushes must be cut away, hollows must be filled up, drainage must be looked out for, and cuts through banks must be made. The engineer must understand how different kinds of soil and rock will behave. Granite, for instance, may be cut almost vertically, and it will

stand firm; but shaly rocks will crumble and slide. Boulders may easily be loosened by a heavy rainfall. Sometimes the slope must not rise more rapidly than one foot in four, or the soil will slide. If the slope is going to be troublesome, it may be cheaper to build a retaining wall or dig a tunnel rather than to buy the land. This often occurs when a road is drawing near to a city, where land is costly.

The older railroads were built by men with shovels and wheelbarrows; but now the steam shovel takes great bites out of the little hills, and they melt away like snowdrifts. To fill up swampy places and hollows, a rough trestle is often built. Cars run on this and dump their loads of earth and gravel, burying the trestle as the work proceeds. Bridges must be constructed and sometimes tunnels must be dug. Ditches for drainage must be made on both sides of the track-bed; and the track-bed itself must be made firm, or "ballasted," with crushed stone, gravel, furnace slag, sand, cinders, or burnt clay. This keeps the road-bed dry, and does a great deal to prevent the "ties" or "sleepers" from decaying. Moreover, it is stiff and firm and so keeps the burden of the train from pressing down with all its weight upon the one spot where the wheel rests for an instant.

On this foundation the ties are laid. More than half the ties in the United States are made of oak; but wood is becoming costly and wooden ties last only about eight years, unless treated with some preservative, and therefore it is probable that be-

fore many years have passed all ties will be made of metal.

Rails were made of wood in the first place, then of iron; but even an iron rail soon wore out. Everybody knew that steel would be the best material for rails, but steel was out of the question till the invention of the Bessemer process made it cheap. The weak part of the track is the place where the ends of the rails meet. The difficulty is that heat expands the steel and cold contracts it. If the ends of the rails were fastened tightly together, then in hot weather the rails would expand and tend to pull up from the ties; while in cold weather they would contract and tend to pull apart at the ends. All sorts of "rail joints," or inventions for keeping the rails in place, have been worked out. The most common one is the angle bar, a sort of splice that is bolted to the rails. Generally care is taken in laying the rails not to have the joints in the two lines come opposite each other.

After the road is completed comes the problem of running the trains. Until within the last few years, the motive power of the railroads has been steam; but the use of electricity is increasing rapidly, especially for passenger service and for short distances. A locomotive has power enough to draw a long train, and therefore it is a waste to use this power to draw only a few cars partly filled with people. In the case of electricity, no more need be used than is required for the service performed. Except for the number of men employed, ten sepa-

Courtesy Atchison, Topeka & Santa Fe Ry.

THE KITCHEN OF A DINING-CAR

In this narrow space dinner is cooked and served for several hundred people. It is a wonderfully compact place and requires special skill on the part of the cooks in order to work at all.

rate cars could be run by electricity as cheaply as one train of ten cars. For long-distance traffic, however, and for heavy freight, the steam locomotive is bound to be more economical.

Providing cars for a road is not the simple matter that it used to be, for now a road must have special cars for fruit, oil, coal, dressed meat, and cattle. In the United States parlor cars and cars for sleeping are usually owned by the Pullman Company, to which the additional fare paid by the passengers goes. This saves the railroad the wear on its own cars; but on the other hand, Pullman cars are heavy and carry fewer passengers than the ordinary day coaches. The Pullman is taken along to add to the comfort of the passengers, but does not pay the railroad as well as do the common cars.

Every detail of making the cars and the locomotives and running them has been worked out from simple beginnings. For instance, in the early days the cars were fastened together with a heavy iron chain. Now strong couplers do the work. To stop a train was at first a slow, lengthy process. It began long before reaching the station. The speed decreased and the brakeman on each car hurried to the open platform and with all his strength set to work to turn a certain horizontal wheel. This wound up a chain and so held a brake, much like that of a wagon, against the car wheels. Instead of this primitive arrangement, there is now under the whole train a pipe which a pump on the locomotive keeps filled with compressed air. Connected with this pipe is a

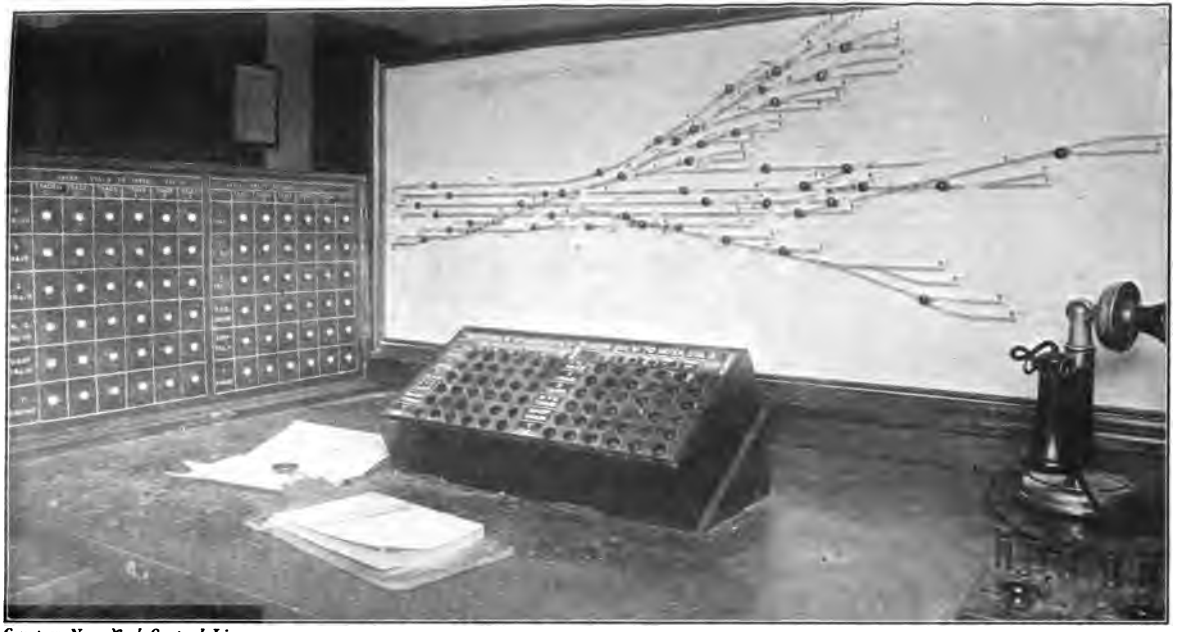
reservoir of compressed air for each car. So long as the pressure of the air in the train-pipe and of the air in the car reservoir is equal, the train speeds on; but either the engineer or the conductor can pull a cord which lets air out of the train-pipe. Then the pressure of the air from the reservoir is so much greater than that from the train-pipe that, by a skillful arrangement of valves, it rushes into the brake cylinder with great force and applies the brakes. By the air brake, a train running at twenty miles an hour can be stopped in one hundred and fifty-eight feet, while the best that the old hand brakes could do was to stop it in ten hundred feet.

In running trains various kinds of signals are used. If a train consisted of a locomotive and two or three cars, running at the speed of a stagecoach, and if there was only one train on a road at a time, it could get along fairly well without signals; but now that freight trains often consist of fifty cars, running perhaps fifty miles an hour, and often only five minutes apart, it is of the utmost importance for several different people to be able to communicate with the engineer. The first of these is the conductor of the train. By means of a bell cord or a tube of compressed air running the length of the train, the conductor can give his directions to the engineer. When the train is in motion, two sounds mean, "Stop at once"; three mean, "Stop at next station"; four, "Reduce speed"; five, "Increase speed." There are also signals by locomotive whistles. One short blast means, "Stop"; two long

blasts mean, "Release brakes." A lantern or flag swung across the track means, "Stop." Raised and lowered in a vertical line, it means, "Proceed." If there is danger ahead, such as a fall of earth or rocks or a bridge washed away, any one may give warning by standing on the track or near it and waving any object violently.

Then, too, there is the semaphore, an upright post with a movable arm at the top, — sometimes two or three arms, one below another. Moving with the arm is an iron frame holding colored glasses and called a spectacle because it used to be made somewhat in the shape of a pair of spectacles. The glasses, passing in front of a lamp, give lights of different colors at night. If the arm is horizontal and the light is red, the train must stop; if the arm is vertical and the light is white (green is used on some roads), the train may go on; if the arm is slanting and the light yellow (green is used on some roads), the train must go slowly and carefully so that it can stop farther along. Some of these signals are moved by a man in a signal tower who may also throw the switches. He works the signals and switches by means of levers that lock one another so that a signal cannot be given unless the switches are right. Torpedoes are sometimes put on the rail to be exploded by the wheels of a train. The sound of a torpedo is a signal to reduce speed and look out for another signal or for something on the track ahead.

One of the best of safety devices is known as the "block system." A "block" is a section of the track



Courtesy New York Central Lines.

HOW THE TOWERMAN HANDLES HIS TRAINS

On the wall is a map of the tracks. A moving red light shows the progress of each train on each track. On the desk is a keyboard with which he signals the next towerman what kind of train is approaching on which track. At the left is a board on which lights flash when the towerman on the other side signals a train to him.

half a mile or sometimes several miles long. At the beginning of each block is a semaphore, worked by men in the towers along the road, or sometimes by the train itself, by the use of electricity or compressed air. This gives the signal "Stop," or "Pass on," or "Go slowly." In Great Britain the block system is required by law.

Every railroad has, of course, a time-table, which states, as some of them put it, when trains "may be expected" to arrive and depart. As a matter of fact, however, whatever "may be expected," it is impossible to time trains to the minute. In Switzerland masses of narcissus blossoms sometimes make the rails slippery and unsafe for rapid progress. Hard-packed snow used to make an engine almost helpless. To break a way through the drifts the rotary snow plough does wonders. It is really an enormous auger which is revolved at high speed by an engine in the car. The snow which is cut away pours out through a pipe that can be turned to either side, and the auger will bore its way through an ordinary drift faster than a man can walk. Hundreds of miles of snowsheds, costing between sixty and seventy dollars a foot, have been built, and countless "glances," or slanting sheds, have been put up in the mountains to turn snowslides away from the tracks. Not only snow and flood may cause delay, but a very slight accident may disarrange the schedule. I remember one train which waited two hours while a brakeman walked back up the track in search of a lost bolt; and another which

lost ten minutes because a cow preferred the railroad track to the road. An excursion or an unusual quantity of freight or express which lengthens the stops at several stations may cause too great a loss of time to be made up in a short run. Extra and special trains are often put on without warning; and even the regular trains are frequently divided into two or three sections. On a busy road there would be a smash-up about once in ten minutes if it were not for the careful train dispatcher.

This official is a cool, level-headed man who sits in his office with a sheet of paper spread out before him. It has to be a sheet of some size, for on it is a record of every train that leaves his terminal. There is much more than the number and the time of leaving and of stopping at each station, for he has also the number of the locomotive, the length of the train, and the names of the crew. At every station the telegraph operator telegraphs to the train dispatcher the time when the train arrives, so that he can tell at any moment just where the train is. If it loses time, he knows it; and if it makes up lost time, he knows that, and on just what part of the road it is made up. If an extra train is put on or a special must have the right of way, he telegraphs that to the station next beyond the train. The operator repeats the message to make sure that he has it correctly. When the train arrives, he gives the message to the conductor and the engine man. Then he telegraphs to the dispatcher that they have received it, and the fact is recorded.

The training given by a first-class railroad to its men is as strict as that given to soldiers by any drill-master. He who has anything to do with a railroad, whether he is a conductor or a small boy selling bananas, soon learns that if he is not punctual, the train is no place for him. The railroad man must obey orders without question or delay. He must attend to his work constantly. If he is negligent one minute in one hour, it is no excuse that he has attended to his business properly for fifty-nine minutes; and to say that he forgot is the same as a confession that he is not fitted for railroad work.

II

HOW THE RAILROADS CARRY MAIL AND PEOPLE

MAIL travels by railroad, steamboat, electric car, wagon, horseback, dog-team, pneumatic tube, and occasionally by aeroplane; but nine tenths of the hauling is done by the railroad. When a railroad undertakes the carrying of mail, it has to agree to a number of requirements. In the large cities the railway post-office cars, for several hours before starting, must stand in a place convenient for the postal clerks. This is not always an easy thing to arrange in a crowded terminal station, but it must be done so that the clerks can begin the assorting of the mail before the train moves. The railway post-office cars are attached to the fastest train, and a mail train must always have the right of way. No matter how large an amount of baggage or express there may be, not one sack of mail may be left behind for the next train, even if it is to follow in five minutes. As a general thing, whenever the usual weight of a single dispatch reaches fifty thousand pounds, trains are made up of mail cars only. The post-office must bring the mail to the cars, but the employees of the railroad must put it on board. In large cities the post-office teams or automobiles carry it from the train to the office; but at the small stations the railroad employees must do this work, provided the office is not more than eighty rods

away. At small terminal stations, however, no matter how distant the office may be, the railroad employees must deliver the mail.

In the mail service the saving of time is a most important matter. Half a century ago, mail bags were loaded into a baggage car, and at the end of the journey they were unloaded; but now a vast amount of work is done while the train is in motion. Postal cars are fitted up like small post-offices, and here the clerks assort the mails. They are required to work two or three days and may spend the following two or three at home; but most of them have "on six days, off six days." To have six days of rest out of every twelve sounds like an easy job; but the strain of the work is so great that longer hours would not be possible. One mail district — for instance, the one which includes the run from Chicago to St. Paul — covers more than twenty thousand post-offices, junctions, and railroad routes. The postal clerk must know all these; he must know the offices of Iowa, Illinois, Indiana, Ohio, Kentucky, and Missouri, and all about the trains running to the southeast. Even more than this, he must know the route of every mail carrier in St. Paul, Minneapolis, and Chicago. Keeping these items in mind, he must distribute mail matter at such lightning speed that the car seems full of flying letters. He has little time to sleep or to eat. There are only so many minutes for the work, and the mail must be assorted whether it is heavy or light. The heaviest regular mails are on Tuesdays; and Christmas is simply a

Courtesy New York Central Lines.

HANDLING THE UNITED STATES MAIL

Mail is brought from the outlying districts of a city by special trolley-cars, wagons, or pneumatic tubes; sorted at the post-office into bags; and then sorted by cities and towns in the railroad cars by the postal clerks.

nightmare to the postal service. In all this wild whirl the postal clerk must be as accurate as if he had all day to assort a handful of letters. Every bundle or sack of mail is marked with the name of the man who distributed it, the date, and the number of the train. If he makes a single mistake, it is set down against him. This record and the results of his examinations determine whether he is to be promoted or not; even if he is the only son of the Postmaster-General, he cannot continue to make mistakes and remain in the service. The Government tried to have the postal clerks wear uniforms; but with a train going fifty miles an hour, with the mercury at perhaps one hundred degrees in the shade, and with as much work as a man can do and live, the matter had to be dropped. The favorite "uniform" is a pair of overalls, some comfortable old shoes, and underclothes to suit the weather.

The life of a railway postal clerk is not an easy one. Six days of such nerve-straining work as this well deserve six days at home; but even these six days are not by any means free for rest. Railroads are constantly altering their time-tables; there are changes in post-offices and in the names of places; and there are often new routes. The clerk must learn all these; and this requires a good deal of study. He is not even free to leave his home, for a Government call may come at any moment, and he must be ready to answer it.

Mails are also distributed by postal clerks on board the ocean steamboats in the same manner

as on the trains, and with the same remarkable accuracy. The average number of mistakes is but one to every four carloads of mail matter. When a steamship is coming into New York, a mail boat goes to the quarantine station for the mails, in order to avoid even a few minutes' delay. If the steamship is not obliged to stop at quarantine, the two boats are sometimes lashed together, and through a big canvas chute the two or three thousand bags of mail, all ready to be delivered in the city or to be put on board the trains, are slid down to the post-office boat as the two steam up to the city side by side.

There are several ways in which every writer of letters can help the hard-working postal clerks of the traveling service and the stationary offices. One way is to mail letters early. Even if they are not to leave the office before midnight, it may save hurry at the last minute if they are posted a few hours earlier. Another great help is to put the stamp in the upper right-hand corner. Stamps are canceled by a machine, and it makes considerable delay if they are put elsewhere. Make the address as clear as possible, and remember that the one who reads it will have only a fraction of a second to give to it. It is a good habit to write your own name and address in the upper left-hand corner. Then if the letter does not find the person to whom it is sent, it will come back to you. Very small envelopes are a special annoyance to every one who has to handle them, because they slip out of a package so easily

and are lost. All these helps to the post-office are equally valuable to the senders of letters, because if the clerks work more easily, the business of the office goes on more rapidly and more accurately.

The expense and the labor demanded from the railroads for carrying mail matter is much greater than that required for carrying express. The payment made by the Government is based upon the weight of the mail carried, the distance, and the number of full-sized railway post-office cars which the road provides and runs. To find the average daily weight of mail on any route, it is weighed each day for one hundred and five consecutive days once in four years. This amount divided by one hundred and five is regarded as the average daily weight, and is counted as such for the four years following. This is not strictly just, because the amount of mail sent is constantly increasing; and when a new service, like that of the parcel post, is introduced, the increase is enormous, although the pay remains the same until the end of the four years.

There are two or three questions about the mails which almost every one has asked at one time or another. Ought we to pay just as much to send a letter across the street as from Maine to the Philippines? In local deliveries of mail, is it fair that a large taxpayer should have but one or two deliveries a day, when a man who pays no taxes at all, but happens to live a quarter of a mile nearer the center of the city, should have five or six deliveries? The answer to such questions is that the Govern-

ment is trying, as far as possible, to treat all citizens alike, whether near or far, rich or poor, and to give them the same service so far as the conditions permit. Like all other public services, the mail service is a compromise; and if the letter sent across the street did not pay more than its delivery costs, the rate to the Philippines would have to be so high that very few people could afford to send letters there. The big, bulky books for the blind are carried at very low rates. The Government pays a mail carrier on a free rural delivery route, for a drive of ten miles to deliver half a dozen letters, as much as it would cost in a city to deliver one hundred letters. Compared with the mail of even a little town in the East, that sent from Nome to Valdez in Alaska is very small; and yet the Government pays more for it than for any other route in the United States, and it is so well managed that in the winter of 1909–10 not one trip was behind time. When any one is about to find fault because one letter in a thousand is a few minutes late, it will be a good thing for him to reflect that our post-offices handle eighteen billion pieces of mail every year; and that it really is one of the greatest marvels of the age that for two cents we can send a letter half around the world with hardly a fear for its safety.

The main business of a railroad is to carry things rather than passengers. There are about two million freight cars in the United States and only one twentieth as many passenger cars. The two kinds of service have entirely different requirements. The

man who sends freight is glad to have it go through promptly, but he will pardon considerable delay if the rates are low. A freight car may be left on a siding a few hours, and no one will find fault. Passengers, on the contrary, demand speed, and if a passenger train was treated in the fashion of the freight train, complaints would come in thick and fast. Freight is not annoyed by discomforts; but people demand comfort, and many of them are willing to pay an extra rate for a fast train and a Pullman car. People require, too, that trains shall run at hours convenient for them, and clamor often arises if a favorite train is taken off. The roads of the United States are especially generous in the matter of baggage. Trunks to the weight of one hundred and fifty pounds may be taken free of charge on each ticket, and are insured to the extent of one hundred dollars. The quantity of hand baggage is practically unlimited.

As a general thing, railroad fares are about two and one half cents a mile, but there is a large amount of traveling at a lower rate. A thousand-mile ticket can usually be bought at a reduction of ten per cent, though some roads require that it shall be used within a year. Fares for round trips and for special excursions are even cheaper. Persons who make the same trip every day, usually between some city and their homes in its suburbs, can buy "commutation tickets" at most reasonable rates. Roads running through sparsely settled regions often have a special immigration department, in charge of a man whose

Courtesy New York Central Lines.

SEVENTY-FIVE YEARS OF RAILWAY TRAVEL

The little picture in the corner shows the first railway station in the United States, still standing at Engine Hill, New York. The big picture shows the great Grand Central Station in New York.

business it is to make himself fully acquainted with the country through which the road runs, and advise newcomers where to go in order to find work, to make their homes, or to establish manufactures. Of late years many roads have spent considerable money in beautifying their suburban railroad stations. It is just as easy to build a pretty little station as a homely one, and if it is surrounded with trees and flowers, even the person who whizzes through it on a fast express carries away from a single glimpse the impression that if the station is so attractive, the town must be equally so. He fancies that it would be a good place for a home, and even if he himself does not settle there, he gives it the best sort of advertising by speaking a good word for it. The manager of a successful suburban road says that six new houses added to a town will pay to its railroad good interest on $5000 or $6000 spent to make the surroundings of the station agreeable. Large cities cannot often spare land about stations for flower gardens; but even a plain retaining bank can be made beautiful if the slopes are sodded and the wall covered with Virginia creeper or honeysuckle or some other vine of rapid growth. Printed advertising is good, but the road that pays heed to the safety and comfort of not only the people in the parlor cars, but the masses of its passengers in coaches, has a valuable advertisement free of cost in the approval of each one who travels on its trains. This approval is a big business asset. A railroad needs friends as much as a person. Good manners on the part of

those connected with a road count immensely. A man who has a thousand dollars to invest is more likely, other things being equal, to buy the bond of a railroad on which conductors answer questions courteously and brakemen are forbidden to slam doors than on one whose general tone is one of incivility and roughness.

The next time that you are in a hurry to cross a railroad track and a long train stops the way, do not be annoyed, but spend the time thinking what the railroads are doing for the country as pioneers in the unsettled parts of it, and as carriers of freight, express, mail, and people.

III

HOW REFRIGERATION BRINGS US FOOD

WHEN we say that food "spoils," we really mean that bacteria, or plants so tiny that they cannot be seen except with a microscope, are living upon it. It is bacteria that cause butter to become rancid and meat to decay. Bacteria are like the fairies of the story-books; there are good ones and bad ones. When they live upon the bodies of dead animals in the woods and crumble them up and destroy them, they are useful; but when they live upon what we want for our own food and spoil it, we try our best to get rid of them.

Some bacteria can be destroyed by drying; others wait contentedly till moisture comes and then set to work again. Heat kills all kinds of bacteria, and that is why boiling or baking any kind of food "sterilizes" it; that is, destroys any bacteria that may be present. Cold kills most bacteria, though some kinds can live comfortably for months frozen in the center of a cake of ice, and can even keep on growing slowly. Nevertheless, since heat cannot be applied to all sorts of food, cold is generally employed to preserve it. The most common way is to shut it up with ice, as in the refrigerator. A good refrigerator should keep food cool and dry. It is not expected to freeze food, but with a reasonable amount of ice it ought to send the mercury down to 40° or 45° F. The air

within should be so dry that crackers and dry cereals put into it will not get damp. Wrapping the ice in flannel delays its melting, but does not keep the refrigerator so cool. Food ought not to be set in at haphazard, but carefully arranged. Whatever needs to be kept coldest should be put directly under the ice. Melons, onions, and other things with a strong odor ought to go near the top, while such things as butter and milk, which absorb odors easily, ought to go near the bottom. There should always be a good circulation of air. The cold air ought to go down below the ice, and after absorbing warmth rise again to be cooled. No one who uses a refrigerator ought to forget that bacteria love warmth and moisture, and that nothing else so discourages them in their mischief as plenty of cold, dry air. A poor refrigerator or one that is not well cared for is worse than none at all.

Less than fifty years ago it was discovered that meat and fruit — in short, all varieties of food — could be sent any distance provided they were kept cold enough while on the way. "Refrigerator cars" were made and were soon running in every direction. These are like the ordinary box cars, but top, bottom, and sides are packed with some "poor conductor" of heat; that is, some substance, like cork or straw or the husks of oats, which will not convey the heat from outside into the car. Across each end there is a compartment to hold ice, which is put in from the top. At the top and bottom of this compartment are openings to allow the air to cir-

culate. Whenever any substance melts, it takes in heat and cools the object from which the heat comes. If a dish of cold water is set upon a hot stove, the water takes heat from the stove, boils, and turns into steam; while the stove under it is cooler than it otherwise would have been. In just this way the ice takes heat from the air of the car and melts, and the air becomes cooler. Salt added to the ice makes it melt faster because salt and water are so eager to unite that they draw heat from the air more rapidly than does the ice alone.

As soon as it had really been proved that a banana or an orange or a piece of meat could be carried a thousand miles and delivered in as good condition as if it had grown only five miles away, people awoke to the possibility of getting their food from the places where it could be produced best and most cheaply. Turkeys from Texas, chickens from Oklahoma, Kansas, or Tennessee, and beef and pork from Chicago are sent from one end of the country to the other. Strawberries are carried from North Carolina to Minnesota and to Massachusetts. Melons journey from Indiana all over the North. Early peaches from Georgia and late peaches from Michigan travel to Maine. Grapes are taken from the Pacific Coast to the Atlantic. Fruit can be bought the year round, and so cheaply that many housekeepers have almost given up canning and preserving.

There are not only cold cars, but cold rooms and buildings for the storage of food until it is needed.

Just how long it may be kept without injury and what degrees of cold are best for different articles are important questions. If the cold is extreme, as it is in the Arctic regions, meat could be kept for centuries. In Siberia an animal called a mammoth, somewhat like an elephant, was once found frozen into the ice. It had been there for thousands of years, but its flesh was so unharmed that the dogs ate it with a relish. In Cleveland, Ohio, the city has built a cold-storage warehouse in which not only dealers but families may store food at a small expense. A housekeeper can buy thirty dozen eggs, for example, when they are cheapest, and store them for nine months for forty cents. One hundred pounds of butter she can store eight months for fifteen cents. Part of the building is a great public market, clean and airy. For sixteen or seventeen dollars a month a dealer may rent a stall and also a cold locker five feet by six, in which he may store his unsold goods. His expenses are small, and therefore he can afford to sell his goods at a low rate.

There are two ways of producing cold. One is by ice, either natural or manufactured; the other is by manufacturing, not ice, but cold itself. Natural ice cannot be found everywhere. Even where it is found, it must be stored till needed; and in many places it is cheaper to make it than to harvest it and keep it. Moreover, unless the water from which it is made is remarkably pure and clean, bits of weeds, grass, straws, and even animal remains may be frozen into it, to say nothing of bacteria, some of which, as has

been said before, are not at all annoyed by being frozen, and are ready to begin work as soon as they are thawed.

There are two common ways of making ice, the can method and the plate method. In the can method, distilled water is generally used; that is, water formed by collecting the steam from an engine. This water tastes oily and unpleasant because some of the machine oil and certain gases coming from the piping are mixed with it. To get rid of these, it has to be boiled in the open air. Then it is cooled in a great tank and filtered, usually through charcoal; and at last it is ready to be made into ice. It is poured into metal cans of the size that the block of ice is to be, and is let down into brine of a temperature of about twenty degrees below freezing. Just as the melted ice and salt in an ice-cream freezer absorb the heat and thus make the cream freeze, so this brine takes the heat from the water in the cans, and ice is formed in them. Of course the water nearest to the walls of the cans freezes first, and whatever air is in it tends to collect in little bubbles in the center. When the water is frozen, the can is lifted by a hoist, sprayed with warm water to loosen the ice from the can, and slid down a chute into the storage room.

When there is a good supply of pure water and the plant is large, the plate system is generally used, and the water is not distilled. A great tank is divided into compartments by partitions sixteen feet long, nine feet deep, and two and one half feet wide.

These partitions are made double and are so arranged that cold brine can flow freely from one to another. Water is poured into the compartments, and then the freezing begins. A plate of ice is formed on each side of every partition. When it is eight or ten inches thick, the brine is drained off and warm brine takes its place. This loosens the plates of ice, and they are lifted up by a hoist and sawed into convenient-sized blocks.

To manufacture ice, then, is easy, provided you have a way to make the brine cold. How this is done is another story. One way has already been mentioned, that of the chemical action which takes place when the salt and ice in a freezer unite and absorb the heat of the cream. Another way is by evaporation, or changing a liquid into a gas. If you wet your finger and hold it up in the air, it will feel colder than the rest of your hand because the water is evaporating and absorbing some heat from your finger. Ether, gasoline, and alchohol evaporate much faster than water, and so will cool your finger sooner. Different liquids boil and turn into vapor or gas at different temperatures. Water becomes steam at 212° F.; therefore this steam cannot cool anything below that temperature — which would be rather hot for cold storage! Alcohol turns into gas at a little over 172°, and ether at 95°. To produce cold below the freezing point, we must have some liquid that will turn into gas at a lower temperature than freezing. The one generally used is ammonia. Common household ammonia is only

water with some ammonia gas mixed with it; but the ammonia used in producing cold is what is called "anhydrous" ammonia; that is, ammonia which is liquid, but which does not contain any water. This will become vapor at 60° below the freezing point, cold enough for any reasonable purpose. If a bottle is filled with this anhydrous ammonia, corked, a bent tube run through the cork, and set into a pail of water, the ammonia will evaporate through the tube, and very soon ice will begin to form on the outside of the bottle. To cool a room with ammonia is very easy. Build it with double walls and fill in the space between the walls with shavings of cork or any other poor heat conductor. Run pipes around the room, fill them with liquid ammonia and give them an opening out of doors, so that the ammonia will evaporate or turn into gas and pass into the air. This would be a very simple and successful cold storage, and there is only one reason why storage rooms are not made in this way. The reason is that neither liquid ammonia nor any other known liquid which turns to gas at a low temperature is cheap enough to be used once and then thrown away. A method has been invented, however, by which the cold-storage people can eat their cake and have it too; that is, they can get the good from their ammonia and yet have it to be used over and over.

The simplest way to do this is to provide three closed tanks. The first must have double walls and the second be full of cold water. A pipe runs from the first through the second and into the third.

Water and anhydrous ammonia are put into the first tank, and this mixture is heated by gas, by electricity, or by a kerosene lamp. The heat makes the ammonia evaporate and its gas rises into the tube, passes through the second tank, is cooled and falls down into the third tank, ready to be used again in the cooling pipes. In the first tank nothing is left but hot water. The heat is now turned off and cold water is poured in between the double walls. This cools the hot water and condenses it so that it takes up less room, and the gas formed in the cooling pipes flows back into the first tank. The heat is now turned on, and the process begins again. There is an automatic device for turning the heat and the cold water off and on as they are needed. While the ammonia is becoming gas, it absorbs a large amount of heat and so chills whatever is near the pipes in the room.

Of course the apparatus for chilling storehouses is more complicated than this, but the principle is the same. The ammonia must be changed from a liquid to a gas, then changed back to a liquid. By a "compressor" the gas is compressed and can then be easily cooled with water of ordinary temperature and changed from a gas to a liquid. Next, it is allowed to enter coils of pipe located in the room to be cooled, where it becomes gas again, and so chills the pipes. Compressed air can be used for cooling, but the apparatus is big and bulky.

There are two ways of cooling a room by the use of ammonia. By the "direct" way the ammonia is

brought into the room through pipes and allowed to evaporate there in coils of pipe. By the "indirect" way the evaporating ammonia cools brine in a tank outside of the cold room, and this brine is then pumped through pipes into coils of pipe in the room. Sometimes air is driven over these cold pipes by fans and then into the room to be cooled. In large markets pipes run along the inside of the counters, carrying cold brine. They are white with frost because they are so much colder than the air that the moisture in the air condenses and collects upon them, just as the moisture in the air of a warm room collects on the outside of a glass of ice water. Sometimes this brine is made with salt; but if the temperature should fall to zero, the brine would freeze and burst the pipes. Therefore, when great cold is needed, the brine is made of calcium chloride, which will not freeze till the air around it is more than fifty degrees below zero.

There is no end to the uses of manufactured cold. It is employed in dairies and in factories for making butter and cheese. Manufacturers of chocolate would miss it greatly, for chocolate melts so easily that the rooms in which it is wrapped and stored and those in which bonbons are dipped must be kept cool even if the mercury outside the factory has gone into the nineties. On the Atlantic and Pacific Coasts and the Great Lakes fish are frozen in large quantities and are not allowed to thaw till they are delivered to the consumers. Fruit and other foods are kept chilled to use in ocean travel. Beef is carried to

England from the United States and Argentina, and rabbits are brought from Australia. Some kinds of ammunition, such as cordite, must be kept cool, and this cannot be done without refrigeration.

Engineers have discovered some most interesting uses for manufactured cold. It is no easy work to dig a tunnel through mud or sand; but the thought occurred to some inventive engineer that he could drive down pipes close together and circulate cold brine through them, and so freeze the mud between the pipes. Then pipes and mud would make a solid wall. No water could get through, and the tunnel could easily be dug. Shafts may be sunk in boggy land by sinking tubes in a circle and circulating cold brine down them. A wall of ice is formed within and without the circle of pipes. Warm brine is then sent into the pipes, they are pulled up, and the holes where they were are filled with concrete. Artificial cold is used to freeze the floors of skating-rinks, to delay the hatching of silkworms, to cure bacon, bleach linen, preserve furs and carpets, chill drinking-water, and to get more butter from cream. Some of its uses are not of special importance, others are of so great value that we should find it hard to do without so powerful a helper. Especially in the matter of the transportation of food from producer to consumer, there is nothing which has had so wide-reaching an effect.

IV

HOW FREIGHT AND EXPRESS ARE MANAGED

WHEN you deliver goods for shipment at a freight-station, the agent of the railroad gives you a shipping receipt. This describes the goods, states the weight, whether the freight charges on the shipment are prepaid or to be collected, your name, the name of the consignee, — that is, the person to whom the goods are to be sent, — and his address.

At the same time the agent makes out a "waybill," which is sent by mail to the agent of the railway at the consignee's station, and a "running slip," which is delivered to the conductor of the freight train which will carry the goods. The running slip gives the destination, the contents of the car, and the consignee's name, and is expected to travel with your shipment just as a ticket travels with a passenger. Other information is added to it as the car moves onward. If the goods are transferred to another car, this must be noted on the running slip. All this information must also be entered on the waybill; and a waybill, therefore, is a sort of diary of its own special piece of freight. The records of these waybills are kept so accurately that if you should go to the freight auditor six or seven years after sending your goods, he could show you in about three minutes his record of them with every detail of their journey.

When the goods arrive at the station to which they were to be sent, the freight bill is put into the cashier's rack, and a postal card is sent to the consignee. This is a notice for him to come and remove them. If the goods have been damaged on the way, this fact is noted and the consignee informed of the extent of the damage.

Freight is moved much faster than it used to be, chiefly because of improved methods of handling and fewer transfers. When railroads were first operated, at the end of the line all the contents of a car were transferred to a car belonging to the next railroad on which it was to travel. To-day, cars of freight intended for delivery in Albany, or Chicago, or Cleveland, or some other big city, are made up and sent straight through from the point of shipment to their destination, perhaps traveling over several lines between the two points.

This "through freight" was an advantage to the shippers, but it gave the railroads a problem to solve. If you notice any freight train, you will see that many of the cars belong to distant roads. How was the railroad to get its cars back from other lines? The answer to that puzzle was the *per diem* — or, *by the day* — system put into effect some years ago, which requires each road to pay the owners forty-five cents every day so long as a car not belonging to it is in its hands. This insures prompt handling of freight and delivery of goods, for forty-five cents per day per car mounts up into a considerable sum very rapidly and every railroad is anxious to get

the cars of other roads off its line as quickly as possible. Each road knows how many cars it ought to have and keeps an accurate record through telegraphic reports of where each car is every day. When a car belonging in New York has made its way to San Francisco, for instance, the plan of the roads is to have it loaded with some commodity going to the Atlantic Coast and returned eastward. As a matter of fact, however, if a road needs cars and some empty ones are at hand, it is much inclined to use them, no matter where they belong; but as a general thing cars which are not needed are returned promptly, while those that are needed are retained for reloading. Many shippers of large quantities of goods or of goods needing peculiar treatment, such as oil, meat, fruit, and some kinds of heavy machinery, own their own cars or lease them from a special company. In such cases, the owner pays the railroad the freight charges, while the railroad pays him a certain mileage rental for the use of the cars.

The amount of freight that you bring to a railroad is an important matter in reckoning the cost of hauling. "Less-than-carload" freight is especially troublesome, because the various lots of freight must be brought into the freight-house and given extra handling, which means extra expense; or sometimes the car must be sent on its way only partly filled. A carload of goods addressed to one consignee is much less trouble, and fifty carloads of goods to one consignee will cost far less than fifty times

the cost of one carload of miscellaneous merchandise addressed to perhaps fifty different consignees. Indeed, it does not cost so very much more to haul loaded cars than empty ones, if they are all going to the same place; and many trains can be run on a track almost as well as a few. So long as a railroad is at work, the money which it cost is bringing in interest; but when road and cars are idle, it is bringing in nothing. This is why — besides the impossibility of allowing its yards and tracks to be used as storehouses — railroads will grant to consignees only forty-eight hours to remove their goods from a car or freight-house.

When a railroad is about to fix a price for any sort of freight, it has to reckon with a number of conditions. Not only is the amount considered, but the weight, the bulk, the care required, and the value to be paid if it is injured or lost. Coal is heavy, furniture bulky, cattle require care, silks are costly to replace. All these things must be taken into account. Then, too, even if crops should fail and there should be no produce to haul from any part of the country, salaries, loss of interest on the cost of the road, cars, stations, etc., must go on, as well as the constant expense of keeping these in order. It is reckoned that these expenses amount to about half the cost of transportation.

There is no one general rule which applies to all articles, and indeed the whole question of freight rates is one which has puzzled many wise heads in both the railroad systems and the National Gov-

ernment. The interstate Commerce Commission and the public service commissions of the various States regulate freight rates and try to give all the patrons of the railroad as fair treatment as possible.

Another part of the work of the railroad is to carry express matter. For this service the express companies make contracts with the road for a year or a term of years. The express business began in the work of William F. Harnden, who carried packages in a valise between New York and Boston and agreed to be responsible for them on the way. From this small beginning rose the great companies that, until the establishment of the parcel post, did practically all the carrying of the country except what went by freight.

The business of the clerk who receives your package at an express office is to see that it is clearly marked and well packed. Of course he cannot open the package to make sure that the packing is properly done; and if you put a glass jar of honey, for instance, into a box without a good supply of something to protect it, the company will not be responsible if it is broken.

The clerk gives you a receipt stating the value of your package according to your own estimate. There is an extra charge if you value it at more than fifty dollars, or more than fifty cents per pound when the weight exceeds one hundred pounds; but if you say to yourself, "It is safe enough anyway," and put its value at fifty dollars when it is really worth one hundred, then, if it is lost, the express

company is responsible for fifty dollars and no more. If you send a valuable package containing jewelry or money or important papers, the clerk will seal it with a generous amount of sealing wax, stamp it with the company's seal, and put it into a safe. If the articles enclosed in any package are easily broken, he will mark it "Fragile": this is an order to the men who will handle the package to treat it as carefully as possible. It is to the advantage of both company and shipper for packages to be delivered in good order; but the men who are to handle yours will also handle thousands of others; and your only safety is to pack your goods properly. If you prepay express charges, your receipt will state this, and a yellow label will be pasted upon your package. If the consignee is to pay, a white label is used.

A waybill is now made out much like that written for ordinary freight, and at a startling rate of speed. In a Chicago express office the star record was of five clerks making out in eight hours 4480 waybills. Freight travels alone, aside from the general care which it may have from the conductor, but express matter is in the care of an "express messenger." He sees to it that money and other packages of small bulk are locked up in his safe; and if his goods are to change cars, he must attend to their transfer and be responsible for their safety. He must endeavor not to put a sewing machine on top of a lady's hat, or permit a package to be carried by its station even if the bell is ringing for the train to start.

When freight arrives at its destination, the consignee is notified, and he must take it away; but when express arrives at the larger places, the express company delivers it, and presents a book to be signed, showing that the consignee has received it. Before he pays any charges, he should look at the label. If there is no label, the expressman must deliver the goods free, and collect from the consignee afterwards if he finds that a mistake has been made.

When one man is handling, as swiftly as possible, thousands of packages in a day, mistakes will happen; and when the same car is to be filled with heavy goods and light, strong goods and fragile, something is sure to be broken occasionally; but the wonder is rather that so little damage comes about. Bees, dogs, cats, and all sorts of live creatures have been forwarded by express.

The custom of sending baggage by express is on the increase, owing chiefly to the lower cost and the convenience of having it taken from your home and delivered where you are going without the trouble of re-checking and transferring on the way. Local baggage delivery companies have high prices, and — especially if one lives beyond the "mile circle" — a suitcase may often be expressed two or three hundred miles and delivered at your door for about the same amount as the charge of a local company for bringing it from the railroad station to your home.

The Interstate Commerce Commission has di-

vided the United States into five great zones. The first extends from northern Maine to Washington, and from the eastern coast to Kentucky. The second includes the Southeastern States; the third, the central portion of the country; the fourth, the Rocky Mountain region; and the fifth, the Pacific Coast. The zones are also divided into blocks, and these blocks are divided into squares. Tables have been prepared so that any one can see for himself what the proper charge should be. If he pays it and sees that the yellow label is put on, the matter of whether a charge is "prepaid" or "collect" is settled.

V

ABOUT COMPRESSED AIR

WHEN you want a bicycle tire to act as a cushion for the wheel, you must fill it with air that is much more compressed than the free air outside it. If a hole is then pricked in the tire, the compressed air will rush out with a good deal of force. If this force could be set to work pumping, it would be almost enough to pump another tire full. Your own muscle moving the bicycle pump puts power into the air in the tire by compressing it; the compressed air held the power fast and did not give it up till it had a chance to come through the hole and expand again.

In one way all kinds of power are alike, namely, they can all do work. In practical use, however, much depends on how the power can be carried from where it is made to where it is needed. The power itself may come from a waterwheel or a windmill or a steam engine or muscle, as in the case of the bicycle pump. If the work to be done is near the source of power, as in a mill or a watch, the power may be carried by gearing; that is, if one wheel revolves and its teeth press upon those of another wheel, that will also revolve. Another way is by belting. Even if the wheels do not touch, a belt may run around the moving wheel and over a second wheel, as with the belt of a sewing machine; then the second wheel will also revolve. Electricity will carry power to a long

distance. Steam will not, because it soon cools and condenses. Compressed air loses very little power.

There are many sorts of machines for compressing air, but the principle of them all is the same — that of the bicycle pump, a cylinder and a piston. The uses for it are so many that it has made the most unlike varieties of work easier to do. The Westinghouse air brake has made rapid trains possible. Compressed air locomotives are especially valuable in mines and quarries, and most of all in powder mills, where all risks of fire must be avoided. A locomotive of this sort is much like a steam locomotive except that, instead of the boiler, tanks are put in to hold the compressed air. These, of course, have to be recharged from time to time.

For many years it has been a favorite dream of inventors that some day people would travel in carriers through tubes, and that the power would be compressed air. This has not yet been a success, but long ago "air tubes" or "pneumatic" tubes were used in Europe to carry telegrams. These tubes were very small, but about a quarter of a century ago, Philadelphia laid two six-inch tubes to connect the main post-office with a branch office a mile away. Since then eight-inch tubes have been introduced into five of our largest cities, and have been very successful. The mail matter is put into cylinders holding five hundred letters each, and in the five cities some twenty million letters a day are shot through the tubes by a current of air.

When these tubes were put in, of course there

were people who were sure that they would not work. "When one of the carriers sticks fast, you will have to dig up the whole line till you come to it," they said. After a while, a carrier did stick fast, but the whole line was not dug up by any means. A pistol was fired into one end of the tube, and by a simple but skillfully contrived apparatus the time between the shot and the echo was found to be 2.793 seconds. It is known that at the temperature of the tube sound travels at the rate of 1101 feet per second. Therefore the distance from the pistol to the carrier and back again was 2.793 times 1101, or 3075 feet. At half that distance away, or 1537 feet, it was declared that the carrier would be found. The distance was measured and a man dug straight down to the tube. The carrier was only a foot or two away, and the break in the pipe was but a few feet farther on.

When George Westinghouse invented the air brake, half a century ago, there was no air pump able to provide him with compressed air enough to stop a train. Therefore he invented one. Some years later his pumps had to be sent to the repair shop, and while the men were at work, it occurred to them that if this wonderful power could stop a heavy railroad train, it might also be able to do some of their labor. This idea was so sensible that manufacturers and inventors set their wits to work, and before long compressors were produced that would work capably and economically.

With the power well in hand, new applications

were soon discovered, besides its use for railroad brakes and as a motive power in engines, locomotives, pneumatic tubes, and for lifting heavy weights. Compressed air is a willing worker, and is ready to apply its strength to anything. It will stop a train on the brink of a precipice, and it will cool a glass of water for a workman in a factory. There is nothing monotonous about its work; but on the long list of its valuable industries "pneumatic" or *air* tools occupy a most important place. By means of them hard work is made easy and slow work is made rapid. In many mines, for instance, cars are run by compressed air; but this is a small convenience compared with what these tools accomplish for the miner. The common way of preparing the coal so that when blasted it will fall properly was, not long ago, for a miner to lie on one side, in a most uncomfortable position, and pick away with a hand pick at the floor level of a wall of coal, until his pick would go in no farther. Now he sits in front of the wall, points his pick at the place where it is to be cut, and the pick does the work. The compressed air is brought to the cylinder of the pick machine in a flexible hose that allows the machine to be moved in any direction. In this cylinder is a piston, and by means of a valve the air drives this piston back and forth. To the end of the piston the pick is fastened. The machine is never tired, and while with a hand pick a man can cut out only four or five tons of coal in a day, with a machine he can cut out from fifty to seventy-five. Any air which escapes from the ma-

chine is an advantage to him because it improves the atmosphere of the mine. By means of cartridges filled with compressed air, coal has been successfully blasted. Pipes ran from the compressor to the cartridges. When the latter were in place and all was ready, a tremendous pressure of air was turned on. This burst the cartridges and brought down the coal. Instead of poisonous gases from gunpowder, cool, fresh air filled the blasting chamber; but the new method proved to be more expensive.

It is the little inventions that make everyday life and work easier. One of the greatest of these little things is the pneumatic hammer. If you want to find out how much pressure it takes to drive a chisel one eighth of an inch, for instance, heap weights on top of it, and you will be surprised to find how much weight is needed. And yet a few blows with a hammer will do the same work. When you strike with a hammer, your own muscles furnish power, and the faster the hammer moves, the greater this power becomes. But another kind of power is helping you. You know how much easier it is to strike down than to strike up; and that is because a force called "gravity" draws everything toward the center of the earth. This force is pulling your hammer down. It has been calculated that a hammer weighing two pounds, and moving, when it touches the chisel, at the rate of thirty-two feet in a second, will, in driving a chisel to cut one eighth of an inch, use as much power as if many hundred pounds of weight rested on the chisel. Strike one nail with a hammer moving

slowly, and another with a hammer moving swiftly; and it will be plain that the speed of the blow has a good deal to do with its power; in short, that a few quick blows accomplish more than many slow ones. This is why the pneumatic hammer is so valuable. It has a cylinder and piston, just as in the case of the coal pick. The workman does not swing it with all his might to get force; the force is in the compressed air. He simply holds the tool up to the place to be hammered and turns on the power. The little piston strikes the tool, and the tool strikes from fifteen hundred to three thousand blows a minute. These blows can at a touch be made light or heavy, as the workman wishes. It is stated that a rivet an inch and a half in diameter can be driven into place in a boiler and headed in five seconds, though it would take two expert workmen three minutes with heavy hammers to do the same work. It is no wonder that makers of boilers and water pipes and ships and workers in railroad shops and foundries delight in the pneumatic hammer. In up-to-date shops, you will see hanging over the workbench a line of air pipe to which tools can be attached all ready to hammer or to drill through steel or any other metal. The railroad shops especially would find it hard to do without the help of compressed air; for it not only hammers and drills, but bends heavy iron, punches holes, shears off bolts, and runs all sorts of machines.

These are a few of the "regular jobs" of compressed air; but it is equally ready to help in any odd bit of work, if the workman only has the wit to em-

ploy it. When the buildings at the World's Fair in Chicago were to be painted, all the painters but one laughed at the idea of doing it in two months. This one put his faith, not in brushes and scaffolding, but in a pneumatic machine that sprayed paint as an atomizer sprays perfumery. The buildings were painted in less than the two months allowed. Trees are sprayed, fences and walls are whitewashed, ships, freight cars, bridges, etc., are now painted in this manner; and it is a pity that everything cannot be, for the paint is not only put on with great evenness, but it is driven into every tiny crevice and so preserves the wood more perfectly than brush work.

The sand blast, or a blast of sand driven by compressed air, is a great help to the workman. The rough surface of ground glass is produced by driving fine sand against it. The harder the material to be cut and the swifter the blast of sand, the faster the cutting proceeds. Sand refuses to cut anything soft. You can hold your hand in a sand blast without being hurt, although it will tingle. You can lay a piece of strong lace over glass, and the sand blast will mark out the pattern on the glass without injuring the lace. Buildings can be cleaned of old and blistered paint before a new coat is put on. Structures of stone are often cleaned of smoke and grime by this blast. It is rather disagreeable for the passers-by, but it does the work rapidly and well.

There is even a pneumatic sand-digger. At the building of the famous Bridge of Tay, the engineers

could not succeed in sinking the cylinders for the piers. Engineers must always be ready to devise a new method of doing their work; and one of those who were working on the foundation suggested running a small pipe from each cylinder into the sand, and connecting an air pump with the top of the cylinder. Then he began to pump the air out of the cylinder. There is an old saying that Nature abhors a vacuum; but it would be more reasonable to say that Nature delights in a vacuum, because she can put something into it. What she put into this vacuum was wet sand; for it was sucked up through the pipe into the cylinder, and was emptied through a trap-door in front, while the air pump was making a vacuum in the second cylinder. As fast as the sand was pumped up, the cylinder sank; and the engineer's new idea was a complete success.

Sheep are sheared by compressed air; and it is claimed that the barbarous cuts often made by careless workmen with shears are done away with. A concrete wall has been given to a tunnel by shooting the concrete at it through a pipe; an air brush has been made with a hollow handle through which the paint is forced in a gentle spray; a street sweeper throws a fine spray before it by means of a series of atomizers, and then sweeps the streets without making a dust; carpet cleaners which blow out the dust from a carpet or suck it up are advertised in every paper — and all these depend for their success upon skillful use of compressed air. In a single year nearly two hundred patents were taken out for devices con-

nected with compressed air. These ranged all the way from a rock drill to an airship.

This good friend of the workman is as valuable under water as in the open air. It is not only pumped into the helmet of the diver, but by its means foundations can be laid under water almost as easily as on dry ground. First, an immense box is built with no bottom, but otherwise air-tight, and on top of it another box, open at the top, is towed to the place where the foundation is to be laid, and the masons begin to lay the stonework in the second box just as if they were on dry land. These boxes are called "caissons." As this masonry grows heavier, the boxes sink until the edges of the lower one have settled into the mud of the bed of the river. Air is now forced into the lower box until what water there was in it has been driven out. The men can now work in this lower room which is filled with compressed air. Connecting the two rooms is an air shaft with an air lock to retain the compressed air in the lower room. Through this air shaft the workmen enter and leave and through this the dirt is removed. As the digging continues, the caisson sinks lower and lower till it comes to good firm material. Concrete is now poured through a pipe into the lower caisson until it is full. The concrete hardens, the upper caisson is removed, and there is a strong, solid pier fastened firmly to the rock, and on top of this pier is built whatever masonry is desired.

Working in caissons has not been found injurious, but all sorts of queer things happen to the men

while in them. They can run up ladders far more easily than in the open air, and they are ravenously hungry, but not thirsty. Every one speaks through his nose, and in a high, shrill voice, but no one can whistle, because in whistling the air in the mouth must be compressed more than the outside air; and in the caisson this is impossible. Taste and smell and hearing are not so keen as usual, and often the men feel pain in their muscles. All these feelings appear while the pressure is increasing. When it stops, they disappear. Sometimes pain is felt by the men when coming from the caisson into the free air, but by spending more time in "locking out," as passing through the air shaft is called, this can be avoided.

Persons suffering from tuberculosis are sometimes treated with compressed air. By one method the patient is put into a room full of it, so that he will absorb more oxygen. By another method, air is pumped out of the room, and he breathes free air through a tube, and thus expansion of the lungs is said to take place.

VI

HOW THE TROLLEY CAR RUNS

If you roll a marble on a carpeted floor, it goes at first fast, then more and more slowly, then stops. The strength of your hand provided the power to make the marble roll, and the friction of the carpet and the air made it stop. If there had been no carpet, the friction would have been less, and therefore the marble would have rolled farther. To keep anything in motion, then, we must provide power and lessen friction. In moving cars, the friction is lessened by laying smooth rails of steel. The power used to move street-cars is generally electricity. Just what electricity is, nobody fully understands; but how it behaves is pretty well known.

For one thing, it likes to travel through certain substances, and not through others. A substance through which it travels easily is called a "good conductor"; one through which it does not travel easily is called a "poor conductor." Steel, for example, is good, and glass is poor. When glass separates steel or any other good conductor from other substances, the steel is said to be insulated, or *put on an island*, which is the meaning of the word. Glass is always put between lightning rods and a house in order to insulate the rod. The lightning then will follow the rod down into the earth, and will not pass through the glass to the house. A path provided

for the passage of electricity is called a "circuit." When this path is clear and free, the circuit is said to be "closed"; if the path is broken anywhere, it is said to be "broken" or "opened."

In the power house of an electric road there is a machine called a "generator," which produces electricity. This electricity travels along the trolley wire, is brought down by the pole to the motors under the car which drive the car wheels, and travels along the rails back to the power house. In that case the circuit is closed; but if a rail or an overhead wire is broken, or if no car is on the track to make the connection between the wire and the rails, the circuit is open. The generator may continue to produce electricity, but the electricity will not travel on the circuit unless the circuit is closed. It will, however, jump a short distance. During an ice storm, when the wire is loaded with ice, a non-conductor, you can sometimes see brilliant colors at the trolley wheel as the car moves along. These are produced as the electricity jumps over a piece of ice to the wire beyond it. A broken rail will make an open circuit. Repairs to rails are especially expensive in a city because the pavement has to be taken up in order to replace them; therefore the tracks are laid with the greatest care, and the rails are either welded or clamped together with steel plates; or else melted metal is poured into a mould at their junction, and after it is cooled, is ground off so smooth that no bump is felt in riding over it.

The motorman must be able to control the speed

of the car easily and quickly. This can be done by two handles. One puts on the brakes; the other increases or lessens the electricity or shuts it off altogether, if that is desired. If the rails are slippery, a wheel may skid. Where the wheel rubs on the rail, a flat place is worn. This becomes larger with use, and a disagreeable noise and jarring motion are the result. Sand sprinkled on the track makes friction, and so prevents skidding and saves the wheel.

The electricity needed to light the cars also comes from the power house; but it has a special little circuit of its own, running from the wire to the track, and passing through the lamps. Heat, too, comes from the electricity. Even though wire is a good conductor, there is, nevertheless, some opposition to the passage of electricity through it. Whenever there is opposition, there is heat. The wire of the heater becomes heated, but it is so slender and so exposed to the air that whatever heat it receives soon passes off. To warm a car, the current is passed through coils of wire, so that the heat radiated from a long stretch of wire is concentrated into a small space. The woodwork is protected by a metal case. The heater is usually placed under the seats of the car with a grating in front of it. There are several switches so that the amount of current can be regulated according to the weather.

Although we speak of "trolley cars," the real "trolley" is not a car by any means, but only the small but very necessary wheel that rolls along the overhead wire. The word itself comes from an old

word meaning a *little ball.* In England a two-wheeled handcart is called a trolley; and the trolley of the electric cars really resembles this. The wheel is usually made of gun metal, and is held against the wire by the pole. Inside the pole is a wire which carries the electricity to the car. The pole itself is made with a cunning arrangement of springs, contrived to keep the pressure of the trolley wheel upon the wire just the same, whether the wire is taut or sagging.

Trolley wires and their supports are no ornament to a city, and in case of fire they are sometimes a great inconvenience. There are two ways of avoiding their use. One is by putting the wires underground; the other is by giving each car its own "storage battery"; that is, an apparatus for storing electricity. When wires are put underground, they are insulated and laid into a conduit or trough below the street level. A narrow slot extends the whole length of the line, and through this what is called the "plough" reaches down from the car and touches two conductors. The electricity passes from one conductor to the plough, through the motor, and back to the other conductor. To build such a road is far more expensive than one with overhead wires, and it has not been found as reliable as the trolley system. Nevertheless, New York City has several hundred miles of conduits for electric-car wires.

Electric locomotives have been very successful. They can easily draw a light train at the rate of sev-

enty miles an hour, and can take their power from an overhead wire, or from what is called the "third rail." This rail is between the track rails or just beyond them, and is connected with a generator at a power station. A much larger amount of electricity can be taken from this rail than from a trolley wire, and therefore this system has been successful in drawing heavy loads. It is not without danger unless well protected, for the third rail carries enough electricity to kill any one who touches it, under certain conditions. Indeed, it is a safe rule never to touch a wire unless you can see both ends of it. Steam has one great advantage over electricity; a locomotive manufactures its power as it goes along, while electricity must be obtained from a power station, and in going a long distance there is considerable loss of power. An attempt has been made to make an electric locomotive which should be really a small "power plant on wheels," and produce its own electricity; but it did not pay. The ideal way to provide power for a car would be to give it a storage battery. It would then require neither overhead nor underground wires. It would have to be light, cheap, certain in its action, and easily controlled. With such a battery a train need have no connection with a power station. The use of the storage battery has, however, not as yet been found practicable for ordinary railway purposes.

Laying rails is costly; and in both England and the United States, the experiment has been tried of running electric cars without rails. In many country

Courtesy New York Central Lines.

HAULING A TRAIN BY ELECTRICITY

Notice the electric locomotive at the head of the train, and the semaphore system over the different sets of local and express tracks.

places trolleys would be very welcome; and with this advantage the number of residents would probably increase. Nevertheless, people do not care to risk their money in building an expensive road on an uncertainty. Putting up poles to hold a trolley wire, however, is a matter of small cost, and if the cars could use the highway without tracks, there would generally be little difficulty in raising the funds necessary for such a road. A trolley will bring to a country district mail, express, and freight. It will not only make it easy for the people living in lonely farmhouses to go to the nearest city, but it will carry to market timber, milk, fruit, vegetables — anything that the farmers have to sell, and save them the long haul to the steam road or the still longer one to a city. From a famous peach farm in New England, fifty carloads of peaches were loaded into wagons, carried to the steam cars, and then to Boston. The following year the steam road had built a connecting trolley line running by the farm. The peaches were picked during the day, loaded into the freight cars of the steam road, hauled by an electric locomotive, carried directly to Boston without change from the farmer's gate to the city, and were on sale at six o'clock the morning after they were picked. The crop consisted of one hundred and fifty carloads, and was marketed at one third of the cost of marketing the fifty carloads of the previous year. A cross-country trolley line brings the farmer much nearer his market and also acts as a "feeder" to the steam road; that is, it provides the road with pas-

sengers and freight. This applies not only to short trips, but also to long journeys. People are influenced by very small things, and even a journey of two or three hundred miles does not seem so long if a trolley is at hand ready to carry you to the station. When trolley lines were first built, there was great alarm lest their low fares and frequent trips should work an injury to the steam roads; but even when both roads run cars between the same places, the steam road has in many cases gained rather than lost. The reason is that the convenience and cheapness of the trolley have brought large numbers of people to make their homes in the country. This increases the amount of freight to be hauled; then, too, many passengers, because of the greater speed of the steam cars or some convenience of terminal or some other reason, travel by the steam road.

The trolleys do a great deal for the country people, but they do fully as much for the city folk, not only by carrying them wherever they wish to go, but by relieving what are called the "congested districts." In every large city manufactories center in some one particular portion of the city, and to live near it is a convenience for the workmen. When many people wish to live in the same place, rents in that place become high, and tenements are stuffed with people who are uncomfortable and are often sick and suffering for lack of air and sunshine. Such places as these are the crowded or "congested districts." Many of these people would be glad to spend a little more time going to their work if they

could live more comfortably. Houses can be built on land which lies away from the center of the city, and is therefore cheaper. Rents will then be so much less that if a man can be sure of a trolley service that is safe, rapid, convenient, and cheap, he can afford to pay car fare instead of high rent. Great Britain and Belgium have run workmen's trains morning and night at four cents for twenty-four miles. Cleveland, Ohio, has a sliding scale of fares intended to give transportation at cost. In ancient times a "city" included the land that it could defend. Today, whatever limits are on the map, a city really includes the land which rapid transit brings within cheap and easy reach of the business and manufacturing districts.

VII

HOW ELEVATED ROADS AND SUBWAYS ARE BUILT

In every large, growing city, the time comes when surface cars, no matter how fast or how frequently they run, cannot carry all the people who wish to ride in them at certain hours. Then, too, the people who do not wish to ride, but who do wish to cross the tracks, object to waiting until a long line of cars has passed. It is almost as bad to have streets congested with cars as to have houses congested with people. The remedy for congested houses is to take some of the people away; the remedy for congested streets is to take some of the cars away. There are two ways of getting rid of the cars. One is to run them on a roadway built above the street; the other is to put them underneath the street.

The first of these, the elevated road, would, of course, be much less expensive than the second if no payment of property damages were required. Steel pillars are set up on both sides of the curb and about sixty feet apart. Girders stretch wholly or partly across the street between every pair of these; and other girders stretch from each of the first set to its next neighbor. On these second girders the ties and rails rest, at a height varying from sixteen to fifty feet or even more above the level of the street. This is the elevated road; and on this track trains of cars run by electricity are constantly passing at a rapid

rate. People are carried swiftly and safely, but the streets are injured for residence, not only because of the noise, but because the passengers can look into the windows of the houses as the trains rush by. The railway companies pay damages to the owners of the property, but this does not make it any more comfortable to live on those streets. Occasionally an elevated station and structure are attractive, like that at Forest Hills near Boston, but as a general thing, the structure on which the cars run is ugly and permits water and dirt to drop through it. Crossing the street under it is a journey of danger to your clothes and discomfort to yourself. In Berlin they do things much better. There the elevated road is really an ornament, for the ironwork is dignified and artistic. Great pains have been taken to deaden the noise by the use of cement, gravel, and pumice stone. The roadway is water-tight, and underneath it is a road expressly for walkers.

Even if few of the American "L" roads are handsome, they are at least safe, for they are built with great care. The foundation of the Boston Elevated Road will support five times the weight that is required of it; the piles, four times; and the concrete, six times. There is hardly a possibility of a poor piece of steel having been used in it, for every "melt" was tested in a testing machine, and if it broke before a certain amount of strain was reached, the whole melt was rejected. The cars are run by electricity, conveyed by a "third rail." This is five inches higher than the rails of the track and rests on

insulated supports just outside them. Pieces of iron called "shoes" are mounted on the cars and close the circuit by sliding along this rail. The block signal system with automatic stops is used, and no train can enter a section until the preceding one has left it. Special precautions are taken to guard against the forgetfulness or illness of the motorman. If he runs by a signal for danger, an arm, which then projects above the track, catches a valve. This puts on brakes and stops the train. To put on power, the motorman must hold a handle in a certain position. If the pressure of his hand is removed, the handle flies back and all power is shut off.

Elevated roads are usually run on what is called the "multiple unit" system. Each car is equipped with electric motors and air brakes which are operated by a controlling apparatus. This apparatus is so connected that a motorman may operate the entire train from either end of any car by the operation of two levers. One of these connects and disconnects the power; the other applies and releases the air brakes on every truck under every car in the whole train at the same instant and to the same extent.

In large cities thousands of workers must be carried to business in the morning and brought home at night. Useful as are the surface and the elevated roads, they are not enough, especially in a city as long and narrow as New York. The subway is the best remedy that has been found, and therefore the New Yorkers set about building one.

This subway is not all subway by any means, since in the northern part of the city the tracks run on stout viaducts in the open air and sunshine. The real underground work extends about fourteen miles, and in building this there were the old problems of engineering and also new problems by the score. It was decided to work aboveground as far as possible, making tunnels only where tunnels were necessary. The general plan was to dig a great trench about twenty feet deep, and wide enough for four railroad tracks and platforms. In this trench, floor, walls, and roof were to be made of steel and concrete, and on the roof the pavement of the street was to be laid. Between the layers of concrete, layers of heavy felt were placed in order to make sure that not a drop of moisture could get through and so make the subway damp.

The real digging was a long way off, however, for a vast amount of hard study had to come first. Under the pavements of New York City is a perfect network of pipes that carry water, heat, gas, and electricity. There are pneumatic tubes, sewers, and elevated railroad foundations. Before the route of the subway could even be thought of, every old map and plan and record of the city must be examined to see just where these pipes lay. The subway must avoid as many obstacles as possible, and yet it must run in such a way as to accommodate the people who would use it. At length the route was chosen, and the next question was what sort of material would have to be dug through. The only way to find

this out was by boring. So the men with the boring apparatus set to work. They bored holes twenty-five feet deep, and only twenty feet apart, the whole length of the proposed route, some sixty thousand of them in all. Now, the board of commissioners knew just what they wanted and about what it ought to cost, and they advertised for a contractor who would build the whole subway, lay tracks, provide cars, what elevators would be needed, stations — in short, put it in shape to be run. He might then run it for fifty years and have the privilege of running it twenty-five years longer at a fair rental. The lowest bid was $35,000,000, and this was accepted. To obtain this amount the city issued bonds. The rental pays the interest on these bonds and one per cent more. At the end of the seventy-five years, and without any increase in taxation, the subway will belong to the city.

After the contract had been made, the digging began. It was decided that this must be done without interfering with street traffic — and it was so done. Streets were narrowed while the digging was going on, but none of them were closed. The underground pipes and tubes and conduits of all sorts were a difficulty, indeed. They were tangled together in every imaginable fashion, and lay, as the contractor said, "piled upon one another like a lot of jackstraws." Digging in a place like that had to be done almost as carefully as making lace. If a pickaxe slipped and its point pricked a hole in a pipe or main, water or gas or sewage might pour out, or

whole districts of telephone or telegraph wires might be put out of commission. There was something else to be considered. After the supporting earth was dug away from under these pipes, they could not be left hanging in the air. In such cases enormous wooden girders were put up, and stout chains, suspended from these, held the pipes in place. Later, many of the pipes were taken up and laid again, but in an orderly fashion close beside the tunnel. One great sewer pipe, nine feet wide and six feet high, running to the westward, was much in the way. The route had to cross it, but the ground was too low to drop it under the subway trench. In this case a new sewer was built, running to the eastward; and the work of the trench moved on.

One of the greatest difficulties to be met was running the subway under the great Columbus Monument. It weighs one and one half million pounds. Its foundation is of masonry, forty-five feet wide and fourteen feet deep. Part of this rests on rock, but nearly three fourths of it rests on earth and sand. The roof of the subway would have to cut a great piece from the masonry of the foundation. To throw this monument one sixteenth of an inch out of plumb might crack the joints or even the stones themselves. It must be kept absolutely perpendicular and so perfectly supported that nothing but an earthquake would disturb it. By skillful management of heavy timber posts, stone masonry, steel beams and columns, and concrete, this was done.

Another engineering feat was to move farther

apart two heavy retaining walls of brick and concrete. They were two hundred feet long, thirteen feet high, and three feet thick, and weighed two hundred tons each. When a wall like this is to be moved, it is the custom to take it down and build it anew; but the engineers were undertaking work that was not the custom, and they determined to save several thousand dollars by moving the walls as they stood. Behind each one they dug a ditch six feet wide, and laid a floor of concrete a very little lower than the foundations of the wall. This floor was for the wall to stand on; and now came the problem how to get it there. This was solved by boring holes under the wall, putting timbers through them, and steel track plates, well greased, on top of the timbers. These timbers rested on cross-sills. Small steel bearing-plates were placed on top of the track plates, and stout oaken wedges were driven between the timbers and their sills. This raised the wall slightly and threw its weight upon the steel plates. Jackscrews were set against the face of the wall, and thus it was moved at the rate of about one foot to the hour. The ends of the track plates were cut off, and liquid cement, poured into the spaces under the plates, made the whole foundation as solid as a rock.

Still another feat was the moving of a tunnel. The general plan of the subway was to dig a great trench, as has been said before. Then a firm concrete floor was laid, and along this heavy frames of strong steel beams were raised. The upright beams of these

frames were only five feet apart. Between them and on top of them concrete was laid, so that this passage way, through which the cars now go, was a great shell of concrete, enormously heavy. When it was decided to widen a part of the tunnel, the question arose whether this mighty shell, weighing more than eighteen hundred tons, could be made wider by moving the roof and one side five and one half feet to the east, and the floor and the other side five and one half feet to the west. By a skillful use of jack-screws this was done, and was the nearest approach to moving a hole that was ever accomplished.

Of course, such a work as this subway could not be carried through without some accidents. Most of the rock that had to be dug through was very hard. This did not matter especially, but the fact that the strata of the rock slanted was exceedingly troublesome. In one place an enormous mass of these strata suddenly slid out of place and the front steps and walls of a line of houses tumbled into the trench.

To enter the New York Subway to-day, you go down some stairs, in most places not more than fourteen feet, pay your five cents for a ticket at a little window, pass through a turnstile, dropping your ticket into a box; and you find yourself on a long platform in the tunnel. There is plenty of electric light, and even sunlight makes its way through the heavy glass of the sidewalk overhead. A convenient newstand is loaded with papers and magazines. Except this and the ticket office and the wooden fittings

of the cars, there is nothing that would burn. The long trains, run by electricity, come up quietly in a trench beside the platform. The doors are flung open, and you step into a car from the level of the platform. The doors are closed, and the train starts gently and rapidly. You rush onward through a well-lighted tunnel lined with white enamel. The steel columns are five feet apart, but you go so fast that they look like the palings of a fence — almost like a row of pins in a paper. Each station has its own color, not only for beauty, but for convenience in recognizing them if one fails to notice the large clear signs on the walls. "Safety first" is the law of the tunnel. The block system is used. The third rail, which brings in the electricity, is so protected that the feet of the most thoughtless workman cannot touch it. If a train should jump the track, a row of heavy pillars would keep it from the next track. Even careless folk who insist upon putting their heads out of the windows are protected against their own will, for the windows open from the top and not from the bottom. The subway trains start in Brooklyn, run under the river to New York, then onward for fourteen miles to the north. Most of the way there are four tracks, two for express and two for local trains. Supposing that you live "up north" and wish to stop at one of the local stations, you can take the express train to its nearest station to your stopping-place, then transfer to the local. The motors can move the trains at the rate of fifty miles an hour. So it is that the great subway of New York

City does its work. The only respect in which it is not successful is that it is too successful, and at the "rush hours," before and after business, people are packed together like a bundle of lead pencils. The subway was hardly completed before it was evident that others would be needed; so this one is perhaps only the beginning of a second New York lying beneath the first.

Chicago has introduced a system of tunnels which is especially interesting. Her business center covers about one and one half square miles. Every day more than a hundred thousand tons of merchandise is hauled through the crowded streets of this district; at one corner one thousand teams passed in a single hour. The city is rapidly making tunnels to extend under the thirty-two miles of these streets and to be given up to teaming and trucking. Every building in the district is to have direct communication with this underground world. Fortunately for Chicago, the streets were laid out on the checkerboard plan, so this is possible. One of the Chicago papers sums up the advantages of the subway in the following paragraph: —

What the subway means to Chicago: — Clean streets, pure air, sunlight for the people, underground subway for freight traffic; just the reverse of New York and London, where the people are put underground, and teaming and trucking given the preference. Coal, ashes, dirt, excavations from building sites, offal, etc., taken off the streets and hauled underground. All the dirt and annoyance are abolished. Every building in the business district is equipped with tunnel communication with every railroad

and steamship line in the world. Freight, merchandise, and fuel are hauled in; ashes, dirt, and refuse hauled out. Uninterrupted free traffic on the surface for the people who walk, drive, or ride in surface and elevated cars. The streets for the people; the tunnels for merchandise, coal, and freight.

VIII

WHAT THE MOTOR CAR IS DOING

IMPROVEMENTS in motor cars are being made every year. The working parts are more carefully fitted and more perfectly oiled, and either ball or roller bearings are used wherever possible. All this lessens friction, which is the motor car's worst enemy. Skill in casting has increased until castings are now more complicated than any one dreamed of attempting a few years ago, and are so perfectly made that in some cases not more than three or four in a hundred are faulty. Cars are made more powerful without increasing their weight; engines are made smaller and run faster with less vibration; a gallon of gasoline will take a car farther than ever before; and last, but not least, prices are becoming lower, not as the result of using poorer materials, but by making increased numbers and by greater skill in manufacturing. No pains are spared to build faster and more perfect cars. To make a single car would cost a small fortune, and a few hours of extra time spent in building it would be of little consequence; but in a factory where several thousand are produced in a year, a saving of half an hour in time, or even five cents in cost on each car amounts to a generous sum at the end of the year. For this reason it pays to use costly machinery that will work ac-

Courtesy Packard Motor Car Co.

FORTY MILES AN HOUR TO A FIRE

More and more automobiles are replacing horse-drawn fire-fighting apparatus, because of the greater speed they give when every minute counts.

Courtesy American Express Co.

HANDLING CHRISTMAS PRESENTS

The big automobile trucks are loading the heavy Christmas packages into special express-cars.

curately and rapidly and sometimes perform several operations automatically.

The inventions which are to be most serviceable are often looked upon at first as nothing but toys. The telegraph and typewriter were greeted merely as interesting novelties; and when the automobile first made its appearance, it was regarded by most people as a contrivance that would entertain folk who had plenty of money to spend, until something else was invented to take its place. It was only a few years ago that people used to turn and gaze after an automobile in the streets, but the machine has already become a necessity. New uses for it are discovered every day, and the average business man questions, not whether he can afford to buy one, but whether he can afford to do without it.

Wise merchants discovered long ago that a satisfied buyer was their best advertisement, and the dealer in motor cars does his best not only to sell a man a car, but *the* car which is best for his purpose. The business man who is undecided whether to buy a motor truck for his deliveries, and if so, what style, can go to one of the transportation bureaus maintained by many of the larger manufacturers and receive help and advice. The agent studies his present delivery system, counts up with him the cost of horse, wagon, driver, food, stable, harness, and repairs; compares it with the cost of the same work by motor truck, and advises him which style of machine is best suited to his needs. Even after a machine has been sold, it is so much to the advantage

of the manufacturer to have it kept in order without inconvenience to the owner that in some of the larger cities, not only is monthly inspection of machines maintained, but a man can bring his motor truck to the service station at night and have any minor repairs completed before business hours on the following morning.

An especially valuable service rendered by the motor car is to haul a fire engine more swiftly than horses can at the times when every moment counts. The suburbs of a city which is served by fire automobiles are much safer for homes. Of course the cost of the machine is more in the first place, but the expense for care and cost of running it is less than the maintenance of horses; and it runs so few miles in a year that almost nothing need be allowed for depreciation.

The motor car that is to give good service must have good roads. The roads in Washington, D.C., are particularly excellent; and the result is that the tires on motor trucks there last twice as long as in Boston, and more than three times as long as in Baltimore. Good roads are an advantage even to the man who never uses either motor or carriage. Rough pavements leave holes and crevices where dust collects; and this dust not only makes trouble with the eyes and lungs, but it also carries germs of disease.

But if the motor car is a valuable friend to the city man, it has done even more for the farmer, and has been especially appreciated in the smaller towns

and country districts of the Middle West. In that part of the country it is not at all unusual to find six or seven hundred cars in a town of less than ten thousand people. The farmer was quick to see the advantages of rapid transportation. An ordinary touring car gives him the benefits of the city. A family ten miles from town can be carried to stores, lectures, theater, church, in less time than the majority of those living in the city can reach the same places on foot or by trolley. Two or three feeble country schools can be united into one good school, now that a few miles of distance do not count. Milk, butter, eggs, chickens, and many other "small products" can be carried to a neighboring city or village. City and country are brought together. The business man can have the pleasures and advantages of the country; and the farmer can have those of the city.

The motor car is never tired, works as well at night as in the morning, and can carry a much larger load than a wagon. Railroad service in freighting is cheap, but hand labor is dear. Whatever goes by freight must be loaded twice and unloaded twice. Therefore, for what the railroad folk call "short hauls," — that is, for forty or fifty miles, — the hand labor is more expensive than the freightage, and transportation by motor is much cheaper.

The motor car on the farm is much less expensive than in the city. A corner of a well-built barn will make a suitable garage. There is plenty of room for storage, and gasoline can be bought in large quanti-

ties. In some places a "visiting chauffeur" whizzes from farm to farm, giving each machine a daily examination and making small repairs. The farmer, however, in his use of agricultural machines, becomes much more at home with machinery than the city man and can do a good share of his own repairing. Tires last much longer in the country than in the city.

This and much besides the ordinary touring car will do for the farmer and his family. The farm tractor will do even more. This is a draught machine with an engine as a source of power. Some tractors will pull six ploughs followed by harrows, and seeders too if desired, as easily as a team pulls one plough. With the aid of certain machinery it will thresh the grain, and when the crop is ready for sale, it will take five wagonloads to market or to the railroad in much less time than a team would need to carry one. Tests made in the wide fields of the West have shown that, with seventy-five gallons of gasoline and the work of two men, twenty-five acres of land can be ploughed in a day. On a farm, however, the planting and the harvesting last for only a short time; but the countless pieces of work that must be done every day are a continual burden. The tractor saves the farmer and his family from many of these. Its engine pumps and churns, chops fodder, fills the silo, shells corn, turns the grindstone, runs the milk separator, and makes electric light for house and barn. The tractor will not injure, but will greatly improve, the roads; for it can be mounted on the

broad-tired wheels of some discarded farm machine, and with its great weight it will do good service as a roller.

The motor car has almost as many uses in war as in peace. Thousands of soldiers have been carried to the front in motor omnibuses and even in taxicabs. Ammunition, fuel, tools, aeroplanes and high-powered guns for attacking them are carried on motor cars. Great searchlights also travel by motor. They are mounted on stands and can be easily wheeled to the desired position and connected by wires to the wagon which provides them with electricity. Heavy guns are dragged on trailers and progress at a speed that is new in warfare. In one carefully arranged test, guns hitched to powerful touring cars were dragged ninety-nine miles in nine and one half hours by the use of eight gallons of gasoline. With horses, that would have taken three or four days. One of the nations engaged in the European War is said to use a prayer of which the following is a portion: "And for those also, O Lord, the humble beasts, who with us bear the burden and heat of the day, and offer their guileless lives for the well-being of their countries, we supplicate thy great tenderness of heart." In moving an army and providing it with supplies, the motor has shown itself so efficient that we may hope for the release of the horse from the terror and agony of the battlefield.

Motor cars sheathed in armor have become common. Even the war chariots of the ancients have been revived in the form of motor wagons weighing

five or six tons, with broad, heavy rollers in front and long, stout knives projecting from the wheels. The object of these is to crush and tear a way through brushwood and even through the most intricate of the barbed-wire entanglements. Food and apparatus for distilling water travel by motor. Numerous motor vehicles serve as field kitchens, others as repair shops complete with dynamos, lathes, and drills; and in these horses may be shod and repairs made to other motor vehicles, aeroplanes, and artillery. Extra tires and parts of the numerous articles to be repaired are carried, and also expert mechanics to do all sorts of repairing at a moment's notice. Even the motor cycle has been much used for bearing dispatches and for scouting.

There is one application of the automobile in war in which everybody may rejoice, and that is its use as an ambulance and field hospital. Some of these ambulances are arranged so that stretchers may be slid into grooves in tiers. Some of the motor field hospitals have glass roofs and are fitted up as operating-rooms. Terrible as is the pain endured in these motors, it would be far worse without them; and to thousands of suffering soldiers, who would otherwise have died on the field, the lift into the ambulance motor has been the first step in a journey toward home and recovery.

IX

TRANSPORTATION BY RIVERS AND CANALS

DID you ever notice how many of the large cities of the world are built on rivers? The people who founded them were wise, for the rivers insure a plentiful supply of water, the land along the banks is fertile, and most of the labor of bringing its productions down stream can be done by the current. After railroads became common, the rivers were often freed from work and left to amuse themselves. Now, however, the railroads cannot manage nearly all the transportation that is needed, and people are turning back to their old friends, the rivers, for help to carry at least the heavy, bulky freight which is so difficult and so expensive to send by rail.

If a stream is navigable, it is a "public" river, and is free to all to take water or ice or to use for fishing, sailing, or bathing. The banks, however, do not belong to the public; and no one has a right to build a wharf or even to walk on the shore above high-water mark to tow his boat without the permission of the owner of the land.

Not many rivers are navigable without considerable assistance. When a road is once made, it stays in place and does not wander away through a valley or spread over a meadow. When a railroad track is once laid, the rails remain where they were put; they are not nearer together one day and farther apart

TRAFFIC ON THE MISSISSIPPI

A stern-wheeler river packet and the 1200-foot by 600-foot raft of logs that it sometimes tows from the woods of Minnesota to the sawmills of Iowa.

another day. At high water, however, a river is an entirely different stream from the same river at low water.

Some rivers have falls or rapids, and the only way to make such streams navigable is to dig a canal around the impassable portion. In general, however, when people set out to train up a river, they have two aims: (1) to make sure of a channel wide enough and deep enough for the vessels that are to use it; (2) to prevent the stream from overflowing its banks.

How to make a good channel depends upon what kind of river you have taken in hand. Suppose that the banks are rather soft. Then a rock or a fallen tree will often drive the current at an angle across the stream. This current will strike the opposite bank and be deflected back again at the same angle, and so will go on for sometimes a long distance downstream in a zigzag course. Wherever it strikes, it will cut out a mass of earth, carry it along, and drop it where the current is least swift. Sometimes a point of land between two cuts is divided from the shore and becomes an island with the chief current of the stream rushing between it and the mainland. The only way to prevent such damage is to protect the banks. This is done by what is called a "revetment." When a bend of the river is to be revetted, the workmen drive a row of stakes around it just where the line of low water would come. At the head of the bend they drive down piles firmly enough to hold a line of barges, which are to lie moored end to

end. Below these another line of barges is moored, and these second barges are loaded with galvanized iron cables and willows about twenty feet in length. Often great mats are woven, sometimes nearly a quarter of a mile long and perhaps three hundred feet wide. They are spread out on the water, then loaded with stone, sunk, and fastened so that they lie on the bottom of the river and prevent the current from washing away the lower part of the bank. To protect the upper part, a hydraulic grader washes it to a slope. Stones are put over it, or perhaps cement with either bricks or gravel. The word "revet" means "to clothe again," and this method of protecting a bank really "clothes" it. On the Mississippi River, five or six hundred miles of bank are revetted in this manner.

To keep the current deep and steady in one line, dikes are often built, stretching from the shore out toward the channel. The water strikes these and drops its load of sand or gravel. This makes new land and drives the water into the central channel. Sometimes a river is induced to make its own dike. Rows of piles are driven where a dike is needed, and quantities of brush are fastened between them. The water flows through these, but drops the soil which it carries, and before long it has made a dam for itself, which keeps the water from the land and forces it into the channel. If the water is low, there is danger of bars. To do away with these, dredging must be done and the sand pump must be put to work. This pumps up sand and water from the place where a

bar is forming, and drops it through long pipes wherever new land is needed.

If a river has a rocky bed, the channel can be deepened by using dynamite under water or by raising and dropping a heavy cutter with a sharp edge. Many rivers with rocky beds are really a succession of long pools separated by ledges which at low water form dangerous rapids. An interesting method of improving such rivers is by building at the lower end of each pool a "collapsible dam" of one kind or another, which will stand up at low water and fall down when a flood comes. The simplest of such dams is the "A frame," in which "A"-shaped trestles are put close together across a stream. They are all fastened to a chain, and can be lowered to let the water through or raised into place to stop it.

In training up a river, the second aim is to keep it from overflowing its banks. If there were forests around the source of every river, the rainfall would neither evaporate nor run away, but would soak into the ground and find its way into the rivers some time after the rain had ceased, and so do a good deal to make their supply of water regular. We cannot hope to preserve as large an area of forest as every river needs, but there are several other methods of helping the streams to remain in their beds. Revetting the soft banks not only helps to make a good channel, but also keeps a river from spreading; so do dikes and the removal of ledges. Reservoirs can be made along the river and connected by locks, so that water can be saved for dry times and navigation need

never be stopped. The most common way, however, is to build "levees," or ridges of earth parallel with the banks of the stream. More than two hundred years ago the early settlers along the Mississippi River found that their best lands were often overflowed. To protect them they built levees, and this has proved to be the best sort of protection.

Building a levee is no slight matter, for it must be done with the utmost care. If a log or stump or bush is found in the levee, the contractor forfeits his compensation and also his bond. This is because, when a stump or log decays, it will leave a hole through which the water may make its way. The long lines of earth are heaped up in a wider rampart than will be needed when the work is done, because after a little the earth will settle. After it is completed, grass is planted over it to protect it from being blown away or washed away.

Of all the dangers that beset a levee, that of a crevasse is the worst. When the water is high, guards pace back and forth, watching closely lest a muskrat or a crawfish should have made a hole through which the water may be making its way. The bank itself may be so water-soaked that it will crumble with the pressure of the flood. Wherever there is special danger, great piles of lumber and earth and bags are heaped up, to be ready if they are needed. Sometimes the water rises so high that the waves beat against the top of the levees and wear them away. To protect these, the engineer covers the tops with bags of sand. If the earth on the land

side begins to slide down, a stout wall of wood must be set up with strong braces and the earth heaped between the wall and the levees. Sometimes in spite of all efforts, the worst occurs and a real crevasse — not a hole, but a great break in the levee — is made. The water rushes through it in torrents, covering acres of the low-lying lands. Then all the men in the vicinity run to the place with sandbags and planks. Timbers are driven down in parallel rows and well braced. If they hold, bags of sand are then dropped between them and the levee. The ends of the broken levee especially must be protected, and this is done by revetting them with bags of sand. No repairs can be begun till the flood has subsided. Crevasses cannot be predicted, but the floods which may cause them can be. Along many rivers gauges are set up at intervals. In time of flood, the height of the water is known and also the speed with which the flood wave is moving. This knowledge is so accurate that a flood in Paris was predicted three days in advance, and when it came to the city, the height of the water varied only half an inch from the prediction. Rivers like the Mississippi and the Nile, which flow through soft material, bring down an immense amount of earthy matter. Some of this the river lets fall on the way; the remainder it drops at its mouth, thus forming deltas and bars. To make a deep channel at the mouth of the Mississippi and give New Orleans a deep and permanent outlet to the sea, two parallel jetties were made which narrowed the channel and kept the water from spread-

ing over the flats. The current, of course, became more rapid, and so the river cut the bar away by its own force.

Training up a river is expensive. Many millions of dollars have already been spent on the Mississippi and many more millions will be needed, — not only here, but on the other large rivers of the United States. This must be looked upon as an investment just as is the building of a railroad. Of course a navigable river is a great benefit to the towns along its banks; but it is also a benefit to the whole country in that coal, grain, oil, iron ore, lumber, flour, rock, bricks — indeed, anything that is heavy and bulky — can be carried more easily and cheaply by water than by rail.

An ideal river for navigation would be rather straight, of uniform depth from source to mouth, with plenty of water, but no floods. It must be free from falls and rapids and shoals. Such rivers are not common, and the nearest approach to them is the artificial canal.

The first name that the word "canal" brings to mind is the famous Panama Canal which separates North and South America. The question of whether this should be a sea-level canal or one with locks was decided in favor of the locks. A lock is a sort of pen. Two of its sides are made of masonry built along the banks; the other two are folding gates or doors across the canal. When a boat is to ascend from a low level of water to a high one, the lower door of the lock is opened. The water within the lock is no higher than

that of the canal below it; so the vessel is easily towed in by electric power. Now the upper gate is partly opened and the water from above flows in slowly till the water in the lock is as high as that above it. The partly opened doors are opened wide and the boat is towed out ready to continue its journey. To go from a high to a low level, the whole operation is reversed. The electric power which opens and closes the mighty gates is operated from a central tower on the higher lock. No vessels pass through the canal under their own steam; all are towed by electric power.

The first important canal in this country was that between Buffalo and the Hudson River. In 1817 the western part of New York State was the "Far West," and some way was needed to bring its products to New York City. Many people laughed at the idea of a canal. Some said it would not hold water; others were sure that it would cost more than all the money in the country; and others declared that it would take fifty years to dig. De Witt Clinton, Governor of New York, believed in it so firmly that the doubters called it "Clinton's big ditch." In eight years it was completed. Much of it ran through a wilderness. It was only forty feet wide and four feet deep; but there were no steam shovels in those days, and it was no small matter to dig with shovels and picks a ditch three hundred miles long, even though it was only four feet deep. Within ten years there were eight thousand vessels upon this canal. The wilderness was speedily settled, and

Courtesy Northern Navigation Co.

LOCKING THROUGH THE SOO CANAL

How a big lake steamer is taken through the locks at Sault St. Marie by electric power.

Courtesy Boston Elevated Ry.

DRIVING A TUNNEL UNDER A RIVER

The great semi-circular frame is the tunnel shield which gauges the size of the tunnel. Through the openings the workmen pick away at the earth, which is carried back through the passage by mule-drawn cars.

farmers sometimes united, built a boat, and floated their own crops to the New York market. It was a pleasant trip for passengers. Only six days and a cost of eighteen dollars, meals and berth included!

The canal flourished, but the railroad was built, and after a while the helpful little waterway was forgotten. Neglected boats lay rotting at the wharves. A few years ago the State of New York decided to spend $128,000,000 in enlarging this canal and making a great waterway across the State. For half the length of this waterway rivers were used; but it is no small work to make a river into a canal; the Mohawk alone has required a number of great dams to make it navigable. One of these, at Herkimer, is what is called a "hook-needle dam." A series of timbers or "needles" is ranged across the stream. They are adjustable, so that much or little water can be permitted to flow past them. Buffalo is several hundred feet above the level of the Hudson at Waterford, north of Troy, where the canal enters the river, and therefore many locks were necessary. At Little Falls is the highest lock in the world. It will raise a three-hundred-foot vessel forty and one half feet without the least difficulty. The lock is supplied with water from tanks close by, and can be filled in five or six minutes.

The water for the new canal comes from Lake Erie, ten thousand gallons a second. Its flow is controlled by a double set of gates, exceedingly strong — as indeed they ought to be if they are to hold back the waters of the Great Lakes. At Pendleton, not

many miles to the eastward, there are also emergency gates. This canal is ten times as long as the Panama Canal. It has used three fourths as much concrete, and will cost in all one third as much, a mighty undertaking for a single State.

Of late much interest has been felt in canals; and it is quite probable that many old ones will be enlarged and new ones dug. There is a story that a young man wished to work his way from Albany to Buffalo on a canal boat, and the work given him was to walk on the towpath and drive the mules that towed the boat! This towing was all done by mules or horses, and the speed was limited by law to five miles an hour, lest the wash should injure the banks; but those were in the days before concrete. Canal boats propelled by steam or electricity will have no difficulty in moving at least twelve or fifteen miles an hour. The old Erie Canal admitted no boats of more than two hundred and fifty tons; the new Barge Canal will admit those of three thousand tons. Canada is enlarging the Welland Canal between Lakes Erie and Ontario. By these two canals the vast amount of wheat raised in the Middle and Western States can be brought to the ocean, so that Duluth and Superior will become practically seaports. The cost of transportation will be much less. It costs now less than half as much to carry grain from Duluth by water as by rail, and when the canals are done, the water rates ought to be still lower.

What the Panama Canal will accomplish is as yet only begun. If war should ever be forced upon us, it

would be a strong naval base to which our warships could withdraw from either ocean for fuel or supplies. It is to be hoped, however, that the victories of the Canal will be those of peace, and that although it separates the two Americas, it will, by making commerce and friendly intercourse swift and easy, serve to bring them more closely together.

X

THE GREAT HIGHWAY OF THE OCEAN

WHEN a railroad train or a trolley car starts out, it must keep to the track. Even an automobile and a carriage demand a road prepared for them. But a ship goes where it will; the whole sea is one great free highway; and perhaps this is why there is a certain charm in watching a vessel leave her moorings and glide off into the wide ocean. A "ship" proper is a vessel with three square-rigged masts, which uses wind as a motive power; but now, even though a ship sails by wind, it usually has an engine to provide power for hoisting the sails and handling the cargo. The sailing vessels built now are mostly schooners. The old schooner had but two masts, and it is not more than fifteen or twenty years ago since many an old sea-captain got out his spyglass and watched eagerly to see a great novelty, a schooner of five, six, or seven masts, sail by.

Sailing vessels, however, must depend upon wind and currents, and compared with steamers they are slow and irregular and uncertain. They do not require as large crews as do steamers, and wind costs nothing, while coal is expensive; but in spite of this, the quickness and regularity of the steamboat has made it pay better than the sailing vessel. The "tonnage" of a vessel is the amount of water that it dis-

places; and now more than three fourths of the tonnage of the world is moved by steam.

When the Pilgrims came from England to Massachusetts, it took them more than two months to cross the ocean. Travelers on the ocean steamers of to-day are not willing to spend more than five days. They demand speed and all the luxuries of a first-class hotel. Companies supply what is called for; and therefore luxuries increase and rates do not decrease; indeed, they cannot unless travelers will be satisfied with simpler accommodations. It is estimated that a steamship company can bring over four or five steerage passengers at the same expense as one first-cabin passenger. It is no wonder that the companies are more eager to have steerage than cabin passengers.

When a vessel comes into port, it is the business of the health officers to make sure that she is not bringing disease into the country. Therefore, they board her, inspect the crew, and get the report of the physician of the ship in regard to the health of the passengers. If the ship can show a "clean bill of health," the cabin passengers are allowed to land. The steerage passengers are taken to the immigrant station. Then follows a careful examination of each one. The United States is a free country, but it would not be fair to its inhabitants to admit people who would injure it and make it an undesirable place for homes. Therefore, if an immigrant is afflicted with a contagious disease, or is a criminal, or has no friends who will be responsible for him in case he is without

Courtesy Cunard S.S. Co., Ltd.

THE AQUITANIA ON THE STOCKS

A transatlantic liner in process of construction in the shipyards looks even bigger than when in the water. Notice that it is higher than the three-story building.

money enough to give him a start in life, it is probable that if he landed he would injure others, or that at least the country would have to support him; therefore he is told that he must return to his former home, and the steamship company that brought him here must carry him back. Of late years some of the companies have recognized the fact that thousands of persons cross the ocean every year who cannot pay cabin rates, but who are, nevertheless, accustomed to living comfortably. For these a "third class" has been formed. Such passengers do not have the luxuries of the first cabin, but they have conveniences and comforts.

Besides conveying people across the ocean, steamers also carry the foreign mails. If a person in Kansas, for instance, drops into a mail box a letter to some one in Paris, the United States Government must carry it to New York or Boston, put it on board a steamer, pay for taking it across the ocean to France, and pay France for carrying it to Paris from the port where it is received. For the ocean service our Government pays liberally. Sometimes it gives the steamship company the money represented by the stamps on the mail matter; that is, provided the steamers fly the flag of the United States. If they fly a foreign flag, they receive only about one fourth as much for letters and less than half as much for other matter. Generally, however, the Government and the steamship company make a contract to run for a number of years. The length of the route and the swiftness and quality of the vessel are

taken into account; and there are a number of conditions to which an American steamship company must agree. The steamer must fly the flag of the United States, and have Americans for officers and for at least half of the crew. The steamers must be so built that in case of need the United States can buy them for transports or cruisers. Under these contracts a ship of the first class — that is, one of iron or steel, of a certain size, and able to run at least twenty knots, or about twenty-three miles an hour receives four dollars a mile for carrying the mail, whether it proves to be little or much. All this is a large expense; but the postage paid and the amount given by foreign countries for carrying the mail which they send here from whatever port it enters to the place to which it is addressed more than covers the cost. It would be cheaper to send our mail by foreign steamships, but the Government plan is to encourage American vessels and seamen, and also to pay for the possibility that in case of need the ship will be taken over by the Government, no matter how inconvenient that may be for the owners.

Formerly the cost of sending mail to foreign countries varied greatly, and in some cases a letter could be sent to one distant land for less than to another not nearly so far away. In 1874 a postal treaty was made at Berne, in Switzerland, which was the beginning of better arrangements. Most of the nations of the world now belong to the "Postal Union," and postage from any one of them to any other is but

five cents on an ounce letter. Between some of them it is only two cents. A particularly convenient arrangement is that of the "reply coupon." If you wish to write to some one in Norway, for instance, and pay the postage on his reply, you can buy at the post-office for six cents a reply coupon which will pay for bringing his reply to your letter across the ocean. With most of the countries in the Postal Union a parcel post has also been established. Once in five years the Governments belonging to this Union send delegates to a Postal Congress whose business it is to decide upon the rules for the foreign mail service and make whatever changes in its management are desirable.

On the ocean, just the same as on the land, an express service is needed. Many articles require more careful treatment and more prompt delivery than can be given to freight, and are perhaps too bulky or too delicate to be sent by mail. Moreover, the express insures against damage, while the post-office insures, not against damage, but only against total loss; although in many cases an article damaged is practically ruined.

So far as the shipper is concerned, expressing on the ocean is the same as on land. He receives a receipt, or, if he has a large shipment, a bill of lading. On the part of the express company, however, there is a difference in the method of sending goods. On land the express company and the railroad make a contract for a length of time. The express company fetches the matter to the railroad, and delivers it to

Courtesy Cunard S.S. Co., Ltd.

HOISTING THE TURBINES ABOARD

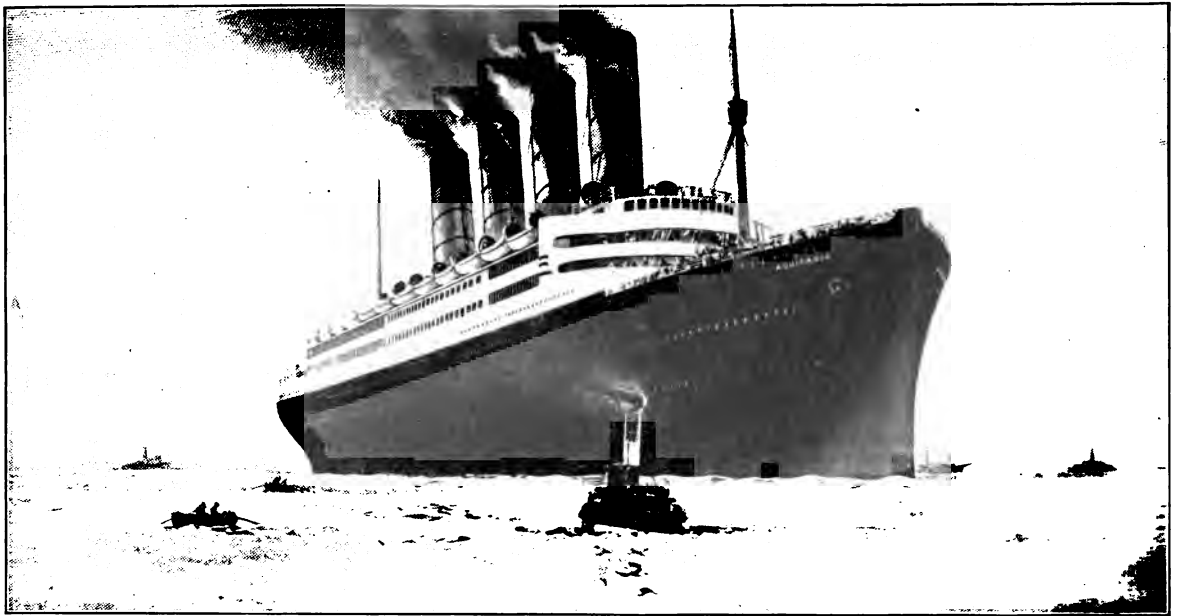
The immense turbine engines which will drive the liner from New York to Liverpool in about five days.

the consignee when it reaches the end of its journey. The railroad provides whatever cars are needed and hauls them. The payment is divided between the express company and the railroad in nearly equal shares. Ocean express is so much less in quantity and so irregular that the express company does not contract with any line of steamers to carry it for a period of time, but forwards it by whatever line is sending out a steamer soonest after it receives the consignment.

Besides passengers, mail, and express, freight is also carried by both steamers and ships; though it is becoming more and more the custom not to carry freight on passenger vessels. Where the amount of freight between two countries is somewhat uniform, a freight line is generally established with fixed dates for sailing. There are "freight forwarders" in many places throughout the country whose business it is to take charge of freight and see that it is carried to a port, and thence to its destination. If you have a cargo of anything that you wish to send across the ocean, you can send it in either of these ways, or you can charter a "tramp" vessel. "Tramps" are not to be despised by any means. They are simply vessels that have not regular routes, but are ready to go wherever any one wishes them to carry a load. If you have a cargo to send away, you call upon a "ship broker" to tell you what vessels are free to do your work. It is the business of these brokers to learn where every vessel is. You make your bargain with a tramp, and your freight is put on board.

Before your vessel is allowed to leave its port, however, you must obtain several important papers. First, you must make out an invoice, or list of your goods and the prices. If you are sending these to Spain, for instance, the resident Spanish Consul must certify that your invoice is correct. This certified invoice, together with a bill of lading, is sent to the consignee in Spain, and before he can get possession of his goods, he must show it to the customs officials. Second, an exact list of all goods on board the vessel, their value, and their destination, must be given to the customs officials of the port and certified. Third, there must be obtained from them a bill of health, declaring that there is no epidemic of dangerous or contagious disease at the port. After all this is attended to, the vessel receives its clearance papers; but before it sails, the Spanish Consul must certify to them; and if the vessel flies, for instance, the Dutch flag, the master must also report to the Dutch Consul that he intends to make the voyage to Spain. These papers are not made out for nothing. Every officer must have his fee. The use of the wharf must be paid for; loading and unloading are costly; sailing vessels must be towed to the wharf, and in many harbors pilots must be employed. Entering and leaving a port is expensive. At the port of Philadelphia, for example, a sailing vessel which carried about two thousand tons of cargo paid over twelve hundred dollars in port charges and fees; one which carried twenty-two hundred and ten tons paid nearly seven hundred dollars.

The ocean carrying business is easy to get into and equally easy to get out of. Vessels of all kinds and sizes can be hired or bought, and they can usually be leased or sold without much trouble, especially if they are for carrying freight. The dangers of the ocean, however, are great, and few people would be willing to invest much of their money in ships if it were not for the system of insurance. To insure a house against fire, you go to the agents of insurance companies and pay so much a thousand on the amount for which you wish the house insured. They give you a paper called a "policy," describing the house and promising to pay you the amount named in case it is burned. Insuring a vessel is quite a different matter. The greater part of the world's insurance of shipping is done in London by an association called Lloyd's. More than two hundred years ago one Edward Lloyd kept a coffee-house in London, which was a favorite place of meeting for merchants and shipowners. Lloyd's little inn held more commercial knowledge than was brought together anywhere else in the world, and after a while he published a weekly paper giving the news of business and shipping. "Lloyd's" to-day is an association of shipowners, merchants, ship and insurance brokers, and underwriters. Their work is divided into three parts. First is the business of insuring vessels; second, the protection of the interests of the members of the association; third, collection of news of shipping all over the world. This news is published in *Lloyd's List*, a paper which is issued



Courtesy Cunard S.S. Co. Ltd.

THE AQUITANIA LEAVING NEW YORK HARBOR

This gives only a faint idea of the immense size and power of a modern transatlantic liner. It is 901 feet long, 97 feet broad, and 92 feet 6 inches deep. It will accommodate 3250 passengers and a crew of 1000.

every morning. There are two classes of members of the association, those who share its advantages but have nothing to do with its management or with insurance, and the underwriters, or those who insure vessels. These underwriters have to deposit a sum varying from twenty-five thousand to fifty thousand dollars as proof that they can pay if an insured vessel is lost.

If a shipowner wishes to insure his ship, his ship-broker goes to Lloyd's and presents a paper giving the name of the ship and her master, describing the cargo, and stating where it is to be taken and at what amount it is valued. Of course before this the vessel has been examined to see whether she is seaworthy and in good order. If her hull and also anchors, cables, and stores are first-class, she is rated as "A1." If her hull is in good condition, but her equipment not so good, she is rated as "A2" or "A3," and so forth. It is from this rating of wooden vessels that "A1" has become a common expression of praise.

If the underwriters decide to insure the vessel, say for twenty thousand dollars, the paper prepared by the ship-broker is passed around among the underwriters, and any member who wishes to share in the risk writes his name under the description — this is why the insurers are called *under*writers — and names the amount for which he is willing to be responsible if the ship is lost. As soon as the twenty thousand dollars has been made up, the shipowner pays the premium required, and the business is com-

pleted. If the voyage results in no mishap, the underwriters are the richer by the amount of the premium paid. If the ship is lost, the loss is divided among a number of men and does not fall upon the owner. This certainty of being paid for the possible loss of a vessel or its cargo has done more than any other one thing to encourage the shipping of the world.

XI

ABOUT ROADS AND BRIDGES

MANY of the older roads in the country grew up from paths through the woods or fields which answered some need of the day, and are by no means in the best positions. Even when roads have been laid out without any such excuse for poor locations, the roadmakers have often been satisfied if they have avoided running the line through the middle of any one's field and have used land that would be of small value for any other purpose.

A road ought to be laid out with the same care that is given to planning a railroad. The first step is to explore the country and decide just where it is to run. Some of this exploring can be done at a study table. The United States Geological Survey has published maps of parts of the country, an area of thirty miles square to a map, and for five cents one of these will be sent to any address. This will show at a glance the hills, valleys, rock-ridges, swamps, and streams of the area. From this map alone an engineer can often mark out two or three promising sites for roads, and by a rapid examination of the country he can then choose among them. The route once chosen, he must make a careful survey and prepare a map with full notes in regard to soil, "cuts and fills," — that is, hills and valleys, — character of the rocks, width and nature of the streams, etc.

He must state where drainage will be necessary; and he must drive stakes one hundred feet apart, following what is to be the middle of the road when completed. He aims, of course, at making the road as short as possible, but it should not exceed a grade of five per cent; that is, he must not let it ascend or descend faster than one foot in twenty, if it can be prevented. If hills stand in the way, he must remember that it is often no farther around a hill than over it and much easier for a load. He must avoid sharp curves. He must cross streams at right angles if possible, and must select favorable places for bridges. If the road is to run along the side of a hill, he must carry it on the southern or western slope if he can, because storms will strike these slopes less severely and will dry sooner. He must not forget that a road is no better than its worst place; for a steep ascent or descent limits the load that can be carried.

The making of the road is of the greatest importance. As a general thing, a team of horses can draw two or three times as heavy a load on a smooth, hard road as on the average earth road; but smooth, hard roads are expensive, and nearly ten elevenths of the roads in this country are earth roads. If an earth road is properly made, however, it is not to be despised. Its worst enemy is water, and therefore, if the ground is soft or spongy, gravel or sand should be put on and tamped down. If the ground is moist, it must be drained. Sometimes ditches beside the roadway will be sufficient; and sometimes drain pipes

are needed. To make sure that the water will not remain on the surface, the road must be "crowned"; that is, the middle must be made higher than the sides. Good road-makers are particular not to put on too much earth at a time. Six thin layers of dirt rolled after each layer will last much better than the same amount of earth put on all at once.

The most annoying sort of road is one of deep sand, where the wheels and the feet of the horses sink in so that they are not traveling *on* the road, but *within* it. Crowning would be a poor way to treat a sand road, because water is good for it, and there is little danger of getting too much. A sand road should have a level surface. Persuade trees to overhang it, if you can, and grass to grow at the side or even in the road; they will help to hold moisture. It has been suggested that sand roads should be made of double width, so that half the width could be used each year and the other half planted with grass.

The great objection to using sand for a road is that it has no "binding power"; that is, every little grain stands by itself and has no wish to cling to any other. Moist clay, on the contrary, clings to whatever is next it — another bit of clay, a grain of sand, a stone, or even your finger. Some kinds of clay crumble to pieces when they are wet, and therefore are not of much value for roads; but others can be worked and kneaded almost as well as putty. This second species of clay is better in road-making because it sticks closely to the sand. If you put a few

grains of sand under a magnifying glass, you will find that they look like sharp, angular pieces of rock. When these are mixed with sticky clay, the fine grains of the clay fill the tiny spaces between the grains of sand. The amount of sand and of clay is important. Too much sand makes a soft, yielding surface; too much clay makes a sticky, disagreeable road whenever it rains. Here, too, part of the work of road-building can be done in a study. Fill one glass with dry sand and another of the same size with water. Then pour into the glass of sand as much water as it will hold. This amount of water will represent the proportion of clay that is needed for the road. A layer of clay must be spread over the sand, ploughed and harrowed and mixed and rolled to the best of the maker's ability, and a fairly good road will result.

Roads are sometimes made of gravel. For light travel, gravel is excellent, but it must be the right sort of gravel, hard, angular, and not much more than two inches in diameter. Loam is often used as a binder; and sometimes the gravel itself is found coated with an iron oxide, which is much better.

A road made of broken stone is called "macadamized," from John McAdam, a famous Scotch engineer. He called attention to the fact that the real weight of hauling is borne by the soil; that so long as the soil is dry, it will support any weight; but that it should be kept dry by putting some kind of protection over it. This protection, he was convinced, should be made of broken stone. He used nothing

for a binder, because he believed that the bits of stone would fit together and make a smooth solid shell that neither rain nor frost would injure. The road which is to receive a macadam surface should be built up carefully and be well drained. It must be crowned and rolled hard and smooth. Over this the broken stone must be spread in layers not more than five or six inches thick, and each layer well rolled. The thickness of the stonework used to be twelve inches or more; but five or six inches now is thought sufficient for most roads. When the work is done and has been thoroughly rolled, whatever binder is needed — sand or dust from screenings — should be spread over the stone, sprinkled, and then rolled again, so that every little crevice will be filled.

Not every species of rock will make a good macadamized road. It must be too hard to wear easily and too tough to break easily; its dust must make a good binder when wet; and it must be uniform. Best of all rocks is the hard trap-rock that was melted inside the earth ages ago and thrown up aboveground, as in the case of the Palisades of the Hudson River and the Giant's Causeway in Ireland. Wherever stone roads are being made, the great powerful crushers may be seen, crunching up rock into small bits, and screening it. No piece may be more than two and one half inches in diameter, and often the stones for the upper layers are not more than two inches.

The coming of the automobile has made it even more desirable to have dustless roads. Unless an

automobile has chain tires, it does not *cause* dust, but it does suck up the dust from between the stones, and the suction caused by the swiftly moving car draws it through the air. Thus far, the nearest approach to a remedy for this disagreeable state of matters is to use as hard stone as possible and a binder that will not blow away, such as tar, bitumen, or oil. The improvement of roads for the convenience of wagons and automobiles is progressing rapidly; but except in a very few places, nothing has been done for the foot passenger. The man who walks has a right to the use of the public road; but as roads are now made and used, he walks on them at the peril of his life. Every road should have a path beside it, strictly limited to the service of foot passengers. Save in damp places, trees should be set out along the road for the good of the road and the pleasure of the walkers. Some of the States lessen the taxes of people who plant trees by the way. Several foreign countries set out fruit trees along their highways. In Belgium a revenue of more than two million dollars has come to the Government annually from the wayside fruit.

However well made roads may be and however well shaded, many of them would be of small value if there were no bridges in the world. Long ago people looked upon the building of a bridge as a deed of charity, and often left money in their wills to put one over some stream or to keep in order one already built.

The man who designs bridges must have imagina-

tion enough to see in his mind just how his bridge will look when it is completed. There is nothing monotonous in his work, for every bridge presents new problems. If the river is broad and shallow, he may plan freely — if sufficient money is allowed — for piers resting on the river bottom, and a bridge made in short spans. If the river banks are low and navigation is desired, a drawbridge may be called for. If the river runs through a gorge, as in the case of the Niagara, the bridge must leap in a single span from shore to shore.

After the general plan of the bridge is decided upon, the engineer sets to work to figure out the kind of material best for his purpose, and the size and shape of every part. He must take into consideration the "live load," — that is, the moving load that the bridge must carry, — and also the "dead load," or the weight of the bridge itself. He must reckon the force of the wind, and he must take account of the effect of heat and cold on metal. In a variable climate, in which the mercury reaches zero or lower in the winter and 100° F. in the summer, an iron bridge half a mile long will vary in length nearly two feet in the course of the year. The builders' roadway, then, must have sliding plates to allow for this, and his rails must be split so as to slide past one another. His plan must show where every bolt and every rivet is to go, and must furnish a perfect guide for the workmen who now set to work to manufacture the separate pieces of metal.

While this is going on, the piers are being laid,

sometimes by driving down iron or wooden piles and sometimes by letting down caissons into the bed of the river, building masonry upon them after they have been sunk low enough, then filling them with concrete. Before the abutments, or foundations on shore, are built, the ground on which they are to stand must be thoroughly examined — not an easy task, for generally it will be below the running water. Rock, of course, makes the best foundations. Clay is good, but if the stratum of clay is thin and quicksand chances to be under it, the bridge might as well be founded upon straw. When all things are ready, the different members of the bridge are riveted together, numbered, and shipped to the river bank. The constructors make these members as large as possible, because the riveting and other fastenings are dóne so much more easily at the factory.

The commonest form of bridge now in use is known as the "truss bridge." A "truss" consists of an upper and a lower "chord," braced firmly by upright and diagonal members. These trusses rest upon piers or abutments. The chords are not mere wires by any means. The lower one is sometimes large enough to drive a load of hay through.

A "suspension bridge" has no piers. For some years the one at Niagara Falls, eight hundred and twenty-one feet in length, was the longest in the world. It crossed the furious river two hundred and thirty feet below, making a single spring over the chasm. In its building, the first slender cord was carried across by a kite. After this bridge had been

in use for nearly half a century, a new one was needed; and one was built not beside, but enclosing the old bridge. The great weight was supported by enormous chains and rods on either shore, and so the bridge was built out in two sections until they almost met. Of course the engineer had calculated just what the distance must be; and when everything was ready, the chains at the shores were loosened, and the two ends came together.

The Quebec Bridge, across the St. Lawrence, has an eighteen-hundred-foot span, the longest in the world. The span of the new bridge from New York City to Brooklyn is two hundred feet less. It is built to allow two elevated railroad tracks, four trolley-car tracks, a driveway, and a footwalk; but of course it is able to support a much heavier load than is at all likely to come upon it. Each wire of its cables is galvanized and oil-coated. The spaces between the wires are filled with heavy grease. A wrapping wire helps to shut out moisture, and paint over all this makes dryness doubly sure. So many cables are used that if all were made by one man, this work alone would keep him busy for almost two hundred years.

The cantilever bridge was not much used until within a few years. The span in the cantilever bridge starts from the abutments, and is so perfectly balanced that it can be built out over the river without any "false work"; that is, any temporary supports. When the two ends are near together, they are connected by another truss span. Such a

Courtesy Boston Elevated Ry.

BUILDING A CONCRETE VIADUCT BRIDGE

The lower picture shows the temporary bridge over which traffic is routed; the upper, the draw-span in the completed structure which lets the boats go through.

bridge cannot fall unless it pushes its shore supports apart.

The man who wishes to plan bridges must be able to invent new ways of working. In one bridge over the Danube River, the false work was laid upon the ice when the river was frozen. In an Australian bridge for which false work could not well be used, the engineeer built trestles upon barges, erected the bridge upon these, floated the barges into the proper place, fastened the bridge to its abutments, let water into the holds of the barges to free the bridge from the trestles, and floated them away. In another instance, one end of the bridge was built on a barge and the other end on shore, resting on a wheeled carriage. When the bridge was done, the barge was towed to the farther shore and one end set in place. The other end was jacked up, freed from the carriage, and put upon its proper abutments.

During the last few years concrete has been most successfully used for bridges. One bridge of this material, in Easton, Maryland, was moulded in Baltimore, sixty miles away. The slabs for the floor, twenty feet long, five feet wide, and one and a half feet thick, were heaped one upon another with a thin film of grease between them. The sides and ornamental railings were also made of concrete. As soon as the piers were set, a top or cap of concrete was cemented upon them, and upon this the concrete slabs for the roadway were swung into their places by great floating derricks. They were lifted by small steel eyelets let into the top of each block

in the moulding. One great advantage in using concrete for bridges is that the final work of setting up the bridge can be done much more rapidly than if stone or iron or even wood was used, and the road need not be long closed. Recently five wooden bridges over railroad crossings showed signs of giving out, and it was decided to replace them with concrete. The abutments were in good order, made of solid masonry, and were ready to be used again. These were stripped and a thick coat of cement spread on top of them. Blocks had been made of reinforced cement and brought to the place. The work of tearing down the old bridges began at nine o'clock one morning. At noon one bridge had been built, and within two days the five bridges were completed. These bridges were used chiefly by farm wagons and were only twelve feet wide; but there would have been the same saving of time in building larger ones.

The man who works on a big bridge is in constant danger. He must walk on narrow girders perhaps three or four hundred feet above the water, girders that a shower or a touch of frost may have made slippery. He must meet whatever winds may blow; for nothing less than a downright gale will stop the work. There is danger all around him, below, and above. A beam may suddenly swing up and brush him from his narrow standing room; a boom may break and a ton of metal drop upon him; and even a hammer falling from a height is no light weight. Many men who are accustomed to meeting danger

in other forms cannot stand the constant strain of bridge-making; but for those who can endure it, there is a strange fascination in the work. And yet every "bridge-man" can tell stories of terrible tragedies high up above the river.

FIRST YEAR IN NUMBER

35 cents net. Postpaid

An Introductory Book to Precede any Series of Arithmetics

BY

FRANKLIN S. HOYT

Formerly Assistant Superintendent of Schools, Indianapolis

AND

HARRIET E. PEET

Instructor in Methods of Teaching Arithmetic, State Normal School, Salem, Massachusetts

The work is based upon the familiar experiences and activities of children, and follows as closely as possible the child's own method of acquiring new knowledge and skill.

Thus we have lessons based on playing store, making tickets, mailing letters, fishing, etc. Every step is made interesting, but no time is wasted in mere entertainment.

By the same authors

THE EVERYDAY ARITHMETICS

THREE-BOOK COURSE		TWO-BOOK COURSE	
Book One, grades II-IV	$ .40	Book One, grades II-IV	$ .40
Book Two, grades V-VI	.40	Book Two, grades V-VIII	.72
Book Three, grades VII-VIII	.45		

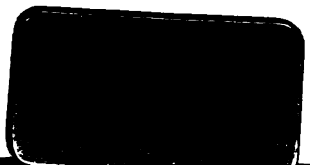
Course of Study (with answers) $ .25

Distinctive Features

1. Their socialized point of view — all problems and topics taken from the everyday life of children, home interests, community interests, common business and industries. 2. Their attractiveness to children — spirited illustrations, legible page, interesting subject matter. 3. The omission of all antiquated topics and problems. 4. The grouping of problems about a given life situation. 5. The development of accuracy and skill in essential processes. 6. The vocational studies. 7. The careful attention to method. 8. The exact grading. 9. The systematic reviews. 10. The adaptation to quick and to slow pupils.

HOUGHTON MIFFLIN COMPANY

BOSTON NEW YORK CHICAGO

1901

This book should be retu
the Library on or before the la
stamped below.
A fine of i
by